INFUSION SYSTEM

For use with the following list numbers:

11971-04 11973-04 12391-04

60529-04 Veterinary Pump

Technical Service Manual

430-95150-007 (Rev. 01/06)

Hospira

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Contents

Section 1

INTRODUCTION 1-1
1.1 SCOPE 1-1
1.2 CONVENTIONS 1-2
1.3 COMPONENT DESIGNATORS 1-2
1.4 ACRONYMS AND ABBREVIATIONS 1-3
1.5 USER QUALIFICATION 1-5
1.6 ARTIFACTS 1-5
1.7 INSTRUMENT INSTALLATION PROCEDURE 1-6
1.7.1 UNPACKING 1-6
1.7.2 INSPECTION 1-6
1.7.3 SELF TEST. 1-7
1.8 BIOMED SETTINGS 1-9
1.8.1 IV PARAMETERS 1-11
1.8.1.1 COMMON IV PARAMETERS. 1-12
1.8.1.2 DEFAULT UNITS/DRUG 1-14
1.8.1.3 MACRO IV PARAMETERS 1-16
1.8.2 ALARMS LOG 1-17
1.8.3 SETTING THE TIME AND DATE 1-18

Section 2

WARRANTY 2-1

Section 3

SYSTEM OPERATING MANUAL 3-1

Section 4

THEORY OF OPERATION 4-1
4.1 GENERAL DESCRIPTION 4-1
4.2 ELECTRONIC SUBSYSTEM OVERVIEW 4-2
4.2.1 CPU SUBSYSTEM 4-2
4.2.1.1 CPU 4-3
4.2.1.2 SYSTEM MEMORY ADDRESS MAP 4-3
4.2.1.3 PROGRAMMABLE READ-ONLY MEMORY 4-3
4.2.1.4 STATIC RANDOM ACCESS MEMORY 4-3
4.2.1.5 CONTROL LOGIC 4-3
4.2.1.6 LCD CONTROLLER 4-4
4.2.1.7 LCD BACKLIGHT CONTROL 4-4
4.2.1.8 LCD CONTRAST CONTROL 4-4
4.2.1.9 REAL-TIME CLOCK 4-5
4.2.1.10 VOLTAGE MONITOR WATCHDOG TIMER 4-5
4.2.1.11 ANALOG-TO-DIGITAL CONVERTER 4-6
4.2.1.12 DIGITAL-TO-ANALOG CONVERTER 4-8
4.2.1.13 FRONT PANEL KEYPAD MATRIX 4-8
4.2.1.14 FRONT PANEL [ON/OFF] KEY 4-8
4.2.1.15 FRONT PANEL LED INDICATORS 4-8
4.2.1.16 KEYPAD LOCKOUT INTERFACE 4-9
4.2.1.17 NURSE CALL INTERFACE. 4-9
4.2.1.18 AUDIBLE INDICATORS 4-9
4.2.1.19 BARCODE READER INTERFACE 4-9
4.2.1.20 DATAPORT INTERFACE 4-10

4.2.1.21 POWER SUPPLY INTERFACE 4-10
4.2.1.22 MECHANISM INTERFACE 4-11
4.2.2 POWER SUPPLY SUBSYSTEM 4-13
4.2.2.1 MAIN SWITCHING REGULATOR. 4-13
4.2.2.2 MAIN REGULATOR FAULT DETECTION 4-14
4.2.2.3 SYSTEM POWER 4-14
4.2.2.4 AUXILIARY SUPPLIES 4-14
4.2.2.5 POWER CONTROL 4-15
4.2.2.6 BATTERY VOLTAGE MEASUREMENT 4-16
4.2.2.7 BATTERY CHARGE/DISCHARGE CURRENT MEASUREMENT 4-16
4.2.2.8 BATTERY CHARGER 4-16
4.2.3 MECHANISM SUBSYSTEM 4-17
4.2.3.1 MOTORS/MOTOR DRIVE. 4-17
4.2.3.2 MOTOR POSITION SENSORS 4-18
4.2.3.3 V2_5 REFERENCE VOLTAGE 4-19
4.2.3.4 AIR SENSORS 4-19
4.2.3.5 PRESSURE SENSORS 4-21
4.2.3.6 PRESSURE SENSOR CALIBRATION 4-23
4.2.3.7 CASSETTE TYPE/PRESENCE SELECTION 4-23
4.2.3.8 SERIAL EEPROM 4-23
4.3 PRINTED WIRING ASSEMBLIES 4-24
4.3.1 POWER SUPPLY PWA 4-24
4.3.2 PERIPHERAL PWA 4-25
4.3.3 CPU PWA 4-25
4.3.4 DRIVER PWA 4-26
4.3.5 SWITCH PWA 4-27
4.3.6 APP PWA 4-27
4.4 REMOTE MOUNTED PERIPHERALS 4-27
4.4.1 LCD 4-27
4.4.2 SEALED LEAD ACID BATTERY 4-28
4.4.3 BARCODE READER WAND 4-28
4.5 MECHANICAL OVERVIEW 4-28
4.5.1 CASSETTE 4-28
4.5.2 MECHANISM ASSEMBLY 4-30
4.5.2.1 MOTOR AND VALVE ASSEMBLIES 4-30
4.5.2.2 A/B VALVE SUBSYSTEM 4-31
4.5.2.3 INLET/OUTLET VALVE SUBSYSTEM 4-32
4.5.2.4 PLUNGER DRIVE SUBSYSTEM. 4-32

Section 5

MAINTENANCE AND SERVICE TESTS 5-1
5.1 ROUTINE MAINTENANCE 5-1
5.1.1 CLEANING 5-1
5.1.2 SANITIZING 5-2
5.2 PERFORMANCE VERIFICATION TEST 5-2
5.2.1 EQUIPMENT REQUIRED 5-3
5.2.2 INSPECTION 5-3
5.2.3 TEST SETUP 5-4
5.2.4 SELF TEST 5-4
5.2.5 CASSETTE ALARM TEST 5-6
5.2.6 FREE FLOW TEST 5-6
5.2.7 DISPLAY TEST 5-6
5.2.8 KEYPAD VERIFICATION/FUNCTIONAL TEST 5-7
5.2.9 ALARM LOUDNESS TEST 5-8
5.2.10 LOCKOUT SWITCH TEST. 5-9

5.2.11 PROXIMAL OCCLUSION TEST 5-9
5.2.12 PROXIMAL AIR-IN-LINE TEST 5-10
5.2.13 DISTAL AIR-IN-LINE TEST 5-10
5.2.14 DISTAL OCCLUSION TEST 5-12
5.2.15 DELIVERY ACCURACY TEST 5-14
5.2.16 NURSE CALL TEST 5-14
5.2.17 ELECTRICAL SAFETY TEST 5-15
5.2.18 END OF THE PVT 5-15
5.3 PERIODIC MAINTENANCE INSPECTION 5-15
5.4 BATTERY OPERATION OVERVIEW 5-16

Section 6

TROUBLESHOOTING 6-1
6.1 TECHNICAL ASSISTANCE. 6-1
6.2 WARNING MESSAGES 6-1
6.3 ALARM MESSAGES AND ERROR CODES 6-2
6.3.1 OPERATIONAL ALARM MESSAGES 6-2
6.3.2 ERROR CODES REQUIRING TECHNICAL SERVICE 6-7
6.4 TROUBLESHOOTING PROCEDURES. 6-13

Section 7

REPLACEABLE PARTS AND REPAIRS 7-1
7.1 REPLACEABLE PARTS 7-1
7.2 REPLACEMENT PROCEDURES 7-3
7.2.1 SAFETY AND EQUIPMENT PRECAUTIONS 7-3
7.2.2 REQUIRED TOOLS AND MATERIALS 7-3
7.2.3 RUBBER FOOT PAD REPLACEMENT 7-4
7.2.4 BATTERY, BATTERY DOOR, AND DOOR PAD REPLACEMENT . . . 7-6
7.2.5 AC POWER CORD, RETAINER, AND VELCRO STRAP REPLACEMENT 7-8
7.2.6 PERIPHERAL ASSEMBLY REPLACEMENT 7-10
7.2.7 PERIPHERAL ASSEMBLY COMPONENT REPLACEMENT 7-12
7.2.7.1 VOLUME CONTROL KNOB REPLACEMENT. 7-14
7.2.7.2 PERIPHERAL COVER REPLACEMENT 7-14
7.2.8 SEPARATING THE FRONT ENCLOSURE, REAR ENCLOSURE, AND MAIN CHASSIS ASSEMBLY. 7-15
7.2.9 FRONT ENCLOSURE, REAR ENCLOSURE, OR MAIN CHASSIS ASSEMBLY REPLACEMENT 7-17
7.2.9.1 SHOE GASKET REPLACEMENT 7-18
7.2.9.2 FRONT/REAR ENCLOSURE GASKET REPLACEMENT . . . 7-18
7.2.10 REAR ENCLOSURE COMPONENT REPLACEMENT 7-19
7.2.10.1 POLE CLAMP EXTRUSION AND BACKING PLATE REPLACEMENT 7-21
7.2.10.2 POLE CLAMP SHAFT/KNOB ASSEMBLY AND SHAFT TIP REPLACEMENT 7-21
7.2.10.3 REAR ENCLOSURE AND HANDLE GASKETS REPLACEMENT 7-22
7.2.11 MINIPOLE ASSEMBLY REPLACEMENT 7-22
7.2.11.1 COTTER RING REPLACEMENT 7-23
7.2.11.2 BAG HANGER REPLACEMENT. 7-24
7.2.11.3 CLUTCH HOUSING REPLACEMENT. 7-24
7.2.11.4 CLUTCH SPRING REPLACEMENT 7-25
7.2.12 MAIN CHASSIS ASSEMBLY COMPONENT REPLACEMENT 7-25
7.2.12.1 POWER SUPPLY PWA REPLACEMENT 7-27
7.2.12.2 KEYPAD REPLACEMENT 7-27

7.2.12.3 DISPLAY REPLACEMENT 7-28
7.2.12.4 CPU PWA REPLACEMENT 7-29
7.2.12.5 PIEZO ALARM REPLACEMENT 7-31
7.2.12.6 MECHANISM ASSEMBLY REPLACEMENT 7-32
7.2.12.7 CASSETTE DOOR AND FLUID SHIELD REPLACEMENT . . . 7-34
7.2.12.8 OPENER HANDLE ASSEMBLY REPLACEMENT 7-37

Section 8
SPECIFICATIONS 8-1

Section 9
DRAWINGS 9-1

Index I-1

Figures

Figure 1-1. Display and Keypad 1-8
Figure 1-2. Biomed Settings 1-10
Figure 1-3. IV Parameters 1-11
Figure 1-4. Common IV Parameters - Version 10.3 1-12
Figure 1-5. Common IV Parameters - Version 11.3 - higher) 1-13
Figure 1-6. Default Units/Drug 1-14
Figure 1-7. Dose Units for Drug 1-15
Figure 1-8. Conc Units for Drug 1-15
Figure 1-9. Macro IV Parameters 1-16
Figure 1-10. Alarms Log 1-17
Figure 1-11. Setting the Time and Date 1-18
Figure 4-1. Serial Interface to ADC 4-7
Figure 4-2. System Startup and Shutdown Timing, Battery Powered 4-15
Figure 4-3. Stepper Motor Coils. 4-18
Figure 4-4. Air Sensor Block Diagram 4-20
Figure 4-5. Pressure Sensor Excitation and Amplifier Block Diagram 4-22
Figure 4-6. Major Elements of the Dual-Channel Cassette 4-29
Figure 4-7. Fluid Path in the Cassette 4-30
Figure 4-8. Mechanism Valve Pins and Sensor Locations. 4-31
Figure 5-1. Display and Keypad 5-5
Figure 5-2. Rear View 5-8
Figure 5-3. Special Cassettes with Bubble Sensor Tips Removed 5-10
Figure 5-4. Distal Occlusion Test Setup 5-12
Figure 7-1. Bottom View 7-5
Figure 7-2. Battery, Battery Door, and Door Pad 7-7
Figure 7-3. AC Power Cord, Retainer, and Velcro Strap 7-9
Figure 7-4. Rear View 7-11
Figure 7-5. Peripheral Assembly Replacement 7-12
Figure 7-6. Peripheral Assembly Components 7-13
Figure 7-7. Separating the Front Enclosure, Main Chassis, and Rear Enclosure 7-16
Figure 7-8. Front Enclosure Gaskets 7-19
Figure 7-9. Rear Enclosure Components. 7-20
Figure 7-10. Minipole Assembly 7-23
Figure 7-11. Main Chassis Assembly Components 7-26
Figure 7-12. Keypad, Display, CPU PWA, and Piezo Alarm 7-30

Figure 7-13. CPU PWA Replacement 7-31
Figure 7-14. Mechanism Assembly Replacement 7-33
Figure 7-15. Fluid Shield Replacement. 7-35
Figure 7-16. Cassette Door and Opener Handle Replacement. 7-36
Figure 9-1. Illustrated Parts Breakdown 9-5
Figure 9-2. Front Enclosure, Rear Enclosure, and Main Chassis 9-7
Figure 9-3. Front Enclosure Assembly 9-9
Figure 9-4. Rear Enclosure Assembly 9-11
Figure 9-5. Peripheral Assembly 9-13
Figure 9-6. Main Chassis Assembly 9-15
Figure 9-7. AC Power Cord, Retainer, and Battery Assembly 9-21
Figure 9-8. CPU PWA and Main Chassis. 9-23
Figure 9-9. Mechanism Assembly 9-25
Figure 9-10. Power Supply PWA Schematic 9-27
Figure 9-11. Peripheral PWA Schematic 9-37
Figure 9-12. CPU PWA Schematic 9-45
Figure 9-13. Driver PWA Schematic. 9-65
Figure 9-14. Switch PWA Schematic 9-71
Figure 9-15. APP PWA Schematic 9-73

Tables

Table 1-1. Conventions 1-2
Table 1-2. System Configuration Data 1-10
Table 4-1. Analog Inputs 4-7
Table 4-2. Keypad Map 4-8
Table 4-3. CPU-Power Supply Interface 4-10
Table 4-4. CPU-Mechanism Interface Signals 4-11
Table 4-5. Power Supply PWA Interface Connections. 4-24
Table 4-6. Peripheral PWA Interface Connections 4-25
Table 4-7. CPU PWA Interface Connections 4-26
Table 4-8. Driver PWA Interface Connections 4-26
Table 4-9. APP PWA Interface Connections 4-27
Table 5-1. Cleaning Solutions 5-2
Table 6-1. Warning Messages 6-2
Table 6-2. Operational Alarm Messages and Corrective Actions 6-3
Table 6-3. Error Codes Requiring Technical Service 6-7
Table 6-4. Troubleshooting with the PVT 6-13
Table 9-1. Drawings 9-1
Table 9-2. IPB for the Infuser 9-2

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Section 1

INTRODUCTION

The Hospira Plum A+® infusion system is an advanced medication management system designed to meet the fluid delivery requirements of today's evolving healthcare environments. With its primary line, secondary line, and piggyback fluid delivery capabilities, the Plum A+® is suited for a wide range of medical, surgical, and critical care applications. Full compatibility with LifeCare® Plum® Series administration sets and accessories make the Plum A+® a convenient and cost-effective infusion system.

1.1 SCOPE

This manual is organized into the following sections:

- ❏ Section 1 Introduction
- ❏ Section 2 Warranty
- ❏ Section 3 System Operating Manual
- ❏ Section 4 Theory of Operation
- ❏ Section 5 Maintenance and Service Tests
- ❏ Section 6 Troubleshooting
- ❏ Section 7 Replaceable Parts and Repair
- ❏ Section 8 Specifications
- ❏ Section 9 Drawings
- ❏ Appendices
- ❏ Index
- ❏ Technical Service Bulletins

If a problem in device operation cannot be resolved using the information in this manual, contact Hospira *(see Section 6.1)*.

Specific instructions for operating the device are contained in the *Plum A+® and Plum A+®3 System Operating Manual*. Provision is made for the inclusion of the system operating manual in *Section 3* of this manual.

Note: The terms "infusion system", "infuser", and "device" are used interchangeably throughout the manual.

Note: Figures are rendered as graphic representations to approximate actual product. Therefore, figures may not exactly reflect the product.

Note: Screen representations are examples only, and do not necessarily reflect the most current version.

1.2 CONVENTIONS

The conventions listed in *Table 1-1* are used throughout this manual.

Table 1-1. Conventions

Convention	Application	Example
Italic	Reference to a section, figure, table, or publication	*(see Section 6.1)*
[ALL CAPS]	In-text references to keys and touchswitches	[START]
ALL CAPS	Screen displays	CASSETTE TEST IN PROGRESS
Bold	Emphasis	**CAUTION: Use proper ESD grounding techniques when handling components.**

Throughout this manual, warnings, cautions, and notes are used to emphasize important information as follows:

WARNING: A WARNING CONTAINS SPECIAL SAFETY EMPHASIS AND MUST BE OBSERVED AT ALL TIMES. FAILURE TO OBSERVE A WARNING MAY RESULT IN PATIENT INJURY AND BE LIFE-THREATENING.

CAUTION: A CAUTION usually appears in front of a procedure or statement. It contains information that could prevent hardware failure, irreversible damage to equipment, or loss of data.

Note: A note highlights information that helps explain a concept or procedure.

1.3 COMPONENT DESIGNATORS

Components are indicated by alpha-numeric designators, as follows:

Battery	**BT**	Diode	**D**	Resistor	**R**
Capacitor	**C**	Fuse	**F**	Switch	**SW**
Crystal	**Y**	Integrated Circuit	**U**	Transistor	**Q**

The number following the letter is a unique value for each type of component (e.g., R1, R2).

Note: Alpha-numeric designators may be followed with a dash (-) number that indicates a pin number for that component. For example, U15-13 is pin 13 of the encoder chip [U15] on the interface PWA.

1.4 ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this manual are as follows:

A	Ampere
AC	Alternating current
A/D	Analog-to-digital
ADC	Analog-to-digital converter
APP	Air, pressure, and pin
BCR	Barcode reader
CCFT	Cold cathode fluorescent tube
CMOS	Complementary metal-oxide semiconductor
CPU	Central processing unit
DAC	Digital-to-analog converter
DC	Direct current
DIP	Dual in-line package
DMA	Direct memory access
DMM	Digital multimeter
DPM	Digital pressure meter
ECG	Electrocardiogram
EEG	Electroencephalogram
EEPROM	Electrically erasable programmable read-only memory
EMG	Electromyogram
EMI	Electromagnetic interference
ESD	Electrostatic discharge
ETO	Ethylene oxide
FPGA	Field programmable gate array
FSR	Force sensing resistor
hr	Hour
Hz	Hertz
ID	Identification
I/O	Input/output
IPB	Illustrated parts breakdown
IV	Intravenous
KB	Kilobyte
Kg	Kilogram
kHz	Kilohertz
KVO	Keep vein open
lbs	Pounds

LCD	Liquid crystal display
LED	Light emitting diode
L/S	Line select
mA	Milliampere
MB	Megabyte
mcg	Microgram
MHz	Megahertz
min	Minute
mL	Milliliter
MMIO	Memory-mapped input/output
MOSFET	Metal-oxide semiconductor field-effect transistor
ms	Millisecond
nF	Nanofarad
ng	Nanogram
Op-amp	Operational amplifier
pF	Picofarad
PROM	Programmable read-only memory
PVT	Performance verification test
PWA	Printed wiring assembly
PWM	Pulse width modulator
RAM	Random access memory
rms	Root-mean-square
RTC	Real-time clock
SCC	Serial communication controller
SCP	Serial communication port
SLA	Sealed lead acid
SMT	Surface mount technology
SPI	Serial peripheral interface
SRAM	Static random access memory
TQFP	Thin quad flat pack
V	Volt
V_{AC}	Volts AC
V_{CC}	Collector supply voltage
VCO	Voltage controlled oscillator
V_{DC}	Volts DC
VSC	5 V_{DC} supply circuitry
VSO	Voltage sweep oscillator
VTBI	Volume to be infused
WDI	Watchdog input

µA Microampere
µL Microliter
µV Microvolt
µsec Microsecond

1.5 USER QUALIFICATION

The infusion system is intended for use at the direction or under the supervision of licensed physicians or certified healthcare professionals who are trained in the use of the infuser and the administration of parenteral and enteral fluids and drugs, and whole blood or red blood cell components. Training should emphasize preventing related IV complications, including appropriate precautions to prevent accidental infusion of air. The epidural route can be used to provide anesthesia or analgesia.

1.6 ARTIFACTS

Nonhazardous, low-level electrical potentials are commonly observed when fluids are administered using infusion devices. These potentials are well within accepted safety standards, but may create artifacts on voltage-sensing equipment such as ECG, EMG, and EEG machines. These artifacts vary at a rate that is associated with the infusion rate. If the monitoring machine is not operating correctly or has loose or defective connections to its sensing electrodes, these artifacts may be accentuated so as to simulate actual physiological signals. To determine if the abnormality in the monitoring equipment is caused by the infuser instead of some other source in the environment, set the device so that it is temporarily not delivering fluid. Disappearance of the abnormality indicates that it was probably caused by electronic noise generated by the infuser. Proper setup and maintenance of the monitoring equipment should eliminate the artifact. Refer to the appropriate monitoring system documentation for setup and maintenance instructions.

1.7 INSTRUMENT INSTALLATION PROCEDURE

CAUTION: Infusion system damage may occur unless proper care is exercised during product unpacking and installation. The battery may not be fully charged upon receipt of the infuser. Do not place the infuser in service if it fails the self test.

CAUTION: Infusion system performance may be degraded by electromagnetic interference (EMI) from devices such as electrosurgical units, cellular phones, and two-way radios. Operation of the infusion system under such conditions should be avoided.

Accessory equipment connected to the analog and digital interfaces must be certified according to the respective IEC standards (e.g., IEC 60950 for data processing equipment, and IEC 60601-1 for medical equipment). Furthermore, all configurations shall comply with the system standard IEC 60601-1-1. Any person who connects additional equipment to the signal input or output part configures a medical system, and is therefore responsible for ensuring that the system complies with the requirements of IEC 60601-1-1. If in doubt, contact Hospira Technical Support Operations *(see Section 6.1)*.

The instrument installation procedure consists of unpacking, inspection, and self test.

1.7.1 UNPACKING

Inspect the shipping container as detailed in *Section 1.7.2*. Use care when unpacking the infusion system. Retain the packing slip and save all packing material in the event it is necessary to return the infuser to the factory. Verify the shipping container contains a copy of the system operating manual.

1.7.2 INSPECTION

Inspect the shipping container for damage. Should any damage be found, contact the delivering carrier immediately.

CAUTION: Inspect the infuser for evidence of damage. Do not use the device if it appears to be damaged. Should damage be found, contact Hospira *(see Section 6.1).*

Inspect the infusion system periodically for signs of defects such as worn accessories, broken connections, or damaged cable assemblies. Also inspect the infuser after repair or during cleaning. Replace any damaged or defective external parts.

1.7.3
SELF TEST

CAUTION: Do not place the infuser in service if the self test fails.

Note: Do not place the infuser in service if the battery is not fully charged. To make certain the battery is fully charged, connect the infuser to AC power for six hours *(see Section 8)*.

Note: If an alarm condition occurs during the self test, cycle the power and repeat the self test. If the alarm condition recurs, note the message and take corrective action *(see Section 6)*. Repeat the self test. If the alarm condition continues to recur, remove the infuser from service and contact Hospira.

To perform the self test, see *Figure 1-1*, and proceed as follows:

1. Connect the AC power cord to a grounded AC outlet. Verify the charge/line indicator **CHARGE** illuminates and an alarm beep sounds.
2. Without a cassette installed, turn on the infuser.
3. The LCD screen briefly displays the **SELF TEST** screen *(see Figure 1-1)*.

   Note: If the **SELF TEST** screen does not appear, contact Hospira.

4. After the self test is complete, the message “INSERT PLUM SET CLOSE LEVER” appears.
5. Verify the time and date. To set the time and date, see *Section 1.8.3*.
6. Open the cassette door and insert a primed cassette. Close the cassette door. The cassette test is complete when the “CASSETTE TEST IN PROGRESS” message disappears.

   Note: The message “MECHANISM INITIALIZATION IN PROGRESS” may briefly appear prior to the “CASSETTE TEST IN PROGRESS” message.

7. A “NEW PATIENT?” message may appear. Press [YES], then turn off the infuser.

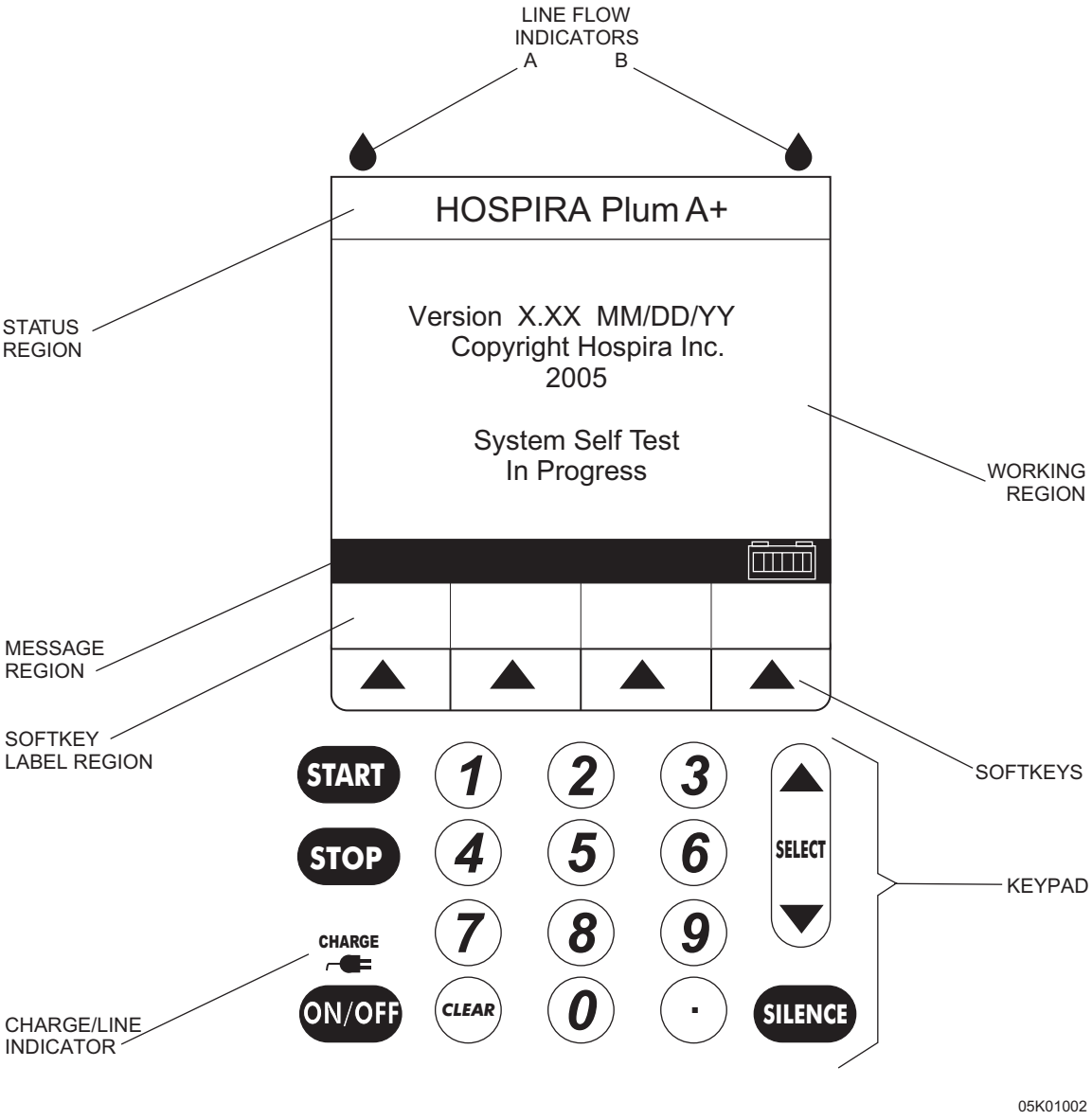

Figure 1-1. Display and Keypad

1.8 BIOMED SETTINGS

The biomed settings screens contain the following options that can be changed or reviewed by qualified personnel:

- IV parameters
- Alarms log
- Set time and date

All infusers (new or refurbished) are shipped with factory settings *(see Table 1-2)*.

Note: Biomed screens do not time out for the **Infuser Idle** alarm or **No Action** alarm.

Note: The battery will not be detected in the biomed service mode.

Note: Upon entry to biomed mode, any drug library waiting for installation will be installed, and the infuser will power off at completion.

To access the biomed settings, proceed as follows:

1. Open the door and turn on the device. The infusion system will perform a self test.
2. After the self test is complete, the message “INSERT PLUM SET CLOSE LEVER” appears.
3. Press the decimal [.] key, then [START], and verify the **BIOMED SETTINGS** screen is displayed *(see Figure 1-2)*.

   Note: The biomed settings screen will display the [CHANGE BATTERY] softkey on Plum A+® software versions 11.4 and higher. [CHANGE BATTERY] does not appear on versions 11.3 and lower.

Table 1-2. System Configuration Data		
Data	**Options Range**	**Factory Setting**
Maximum macro IV mode delivery rate	0.1 - 99.9 mL/hr and 100 - 999 mL/hr	999 mL/hr
Macro distal occlusion alarm (pressure level)	1 to 15 psi	6.0 psi
Deliver together enable	Concurrent or Piggyback	Piggyback
Delayed start/standby enable	Yes or No	Yes
Continue rate	Rate or KVO	KVO
Nurse callback default	Yes or No	No
Time	(24 hr) 00:00 - 23:59 in one minute increments	Factory time
Date	1/1/2002 - 12/31/2098	Factory date

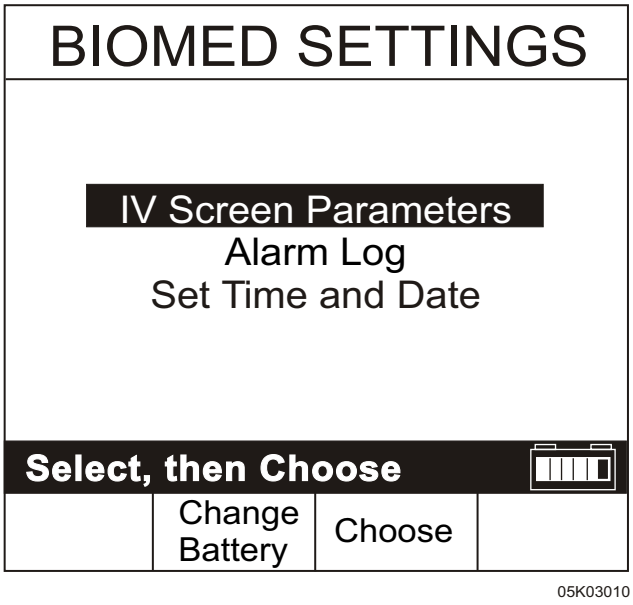

Figure 1-2. Biomed Settings

1.8.1
IV PARAMETERS

The IV parameters screen contains the following:

- Common IV parameters
- Default units/drug
- Macro IV parameters

To change the IV parameters, see *Figure 1-3*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Select **IV Screen Parameters**, and press [CHOOSE].

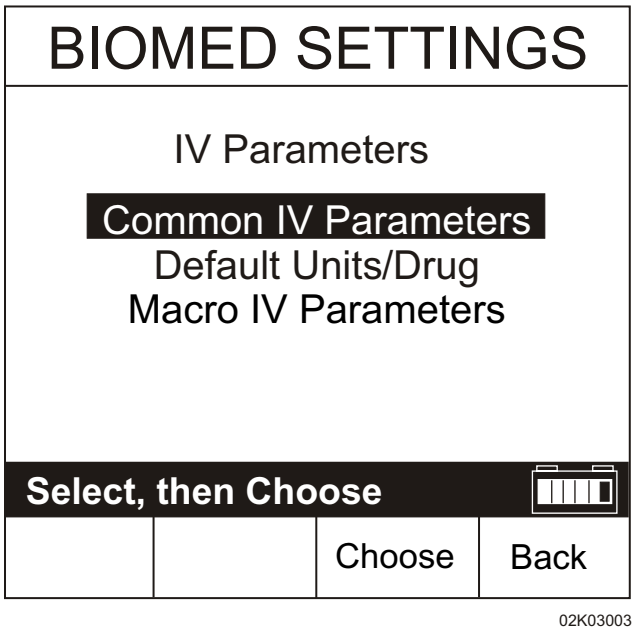

Figure 1-3. IV Parameters

1.8.1.1
COMMON IV PARAMETERS

To view common IV parameters, see *Figure 1-4* or *Figure 1-5*, then proceed as follows:

1. Access the IV parameters screen as described in *Section 1.8.1*.
2. Select **Common IV Parameters**, and press [CHOOSE].
3. Verify the **COMMON IV PARAMETERS** screen is displayed.
4. Select the desired parameter to be changed.
5. Using the [CHANGE VALUE] softkey, select the desired value.
6. Repeat step 4 and step 5 for each parameter to be changed.
7. If there are no other changes to the common IV parameters, press the [CANCEL/BACK] softkey.
8. Verify the **IV PARAMETERS** screen is displayed.
9. If there are no other changes, press the [BACK] softkey to return to the main biomed settings screen, or turn off the infuser.

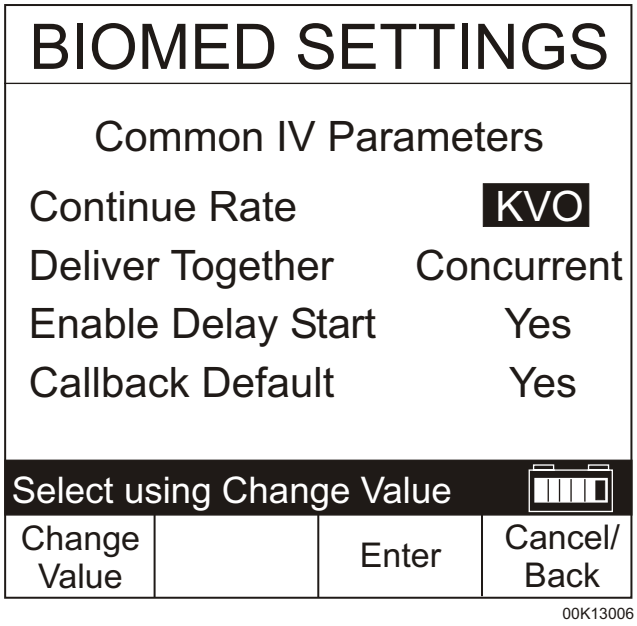

Figure 1-4. Common IV Parameters (Version 10.3)

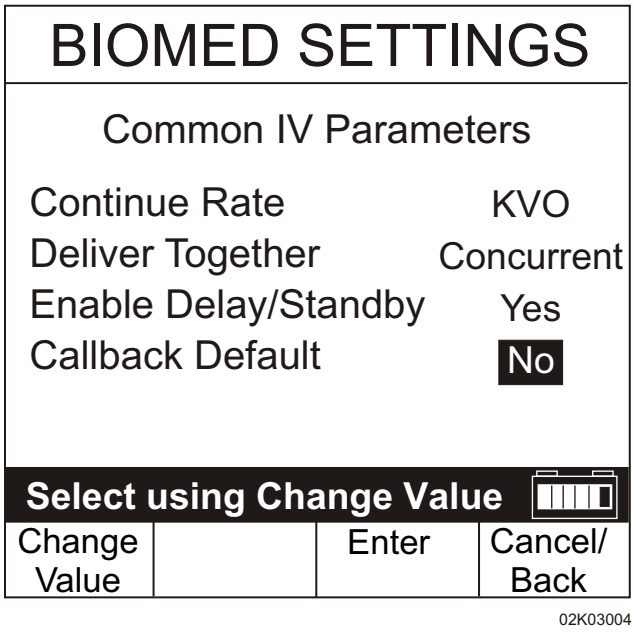

Figure 1-5. Common IV Parameters (Version 11.3 - higher)

1.8.1.2
DEFAULT UNITS/DRUG

Note: For default drug settings, see the system operating manual.

To review or change the default units/drug, see *Figure 1-6*, *Figure 1-7*, and *Figure 1-8*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Access the IV parameters screen as described in *Section 1.8.1*.
3. Select **Default Units/Drug**, and press [CHOOSE].
4. Verify the **DEFAULT UNITS/DRUG** screen is displayed *(see Figure 1-6)*.
5. Using the [PAGE UP] and [PAGE DOWN] softkeys, select the desired drug and press [ENTER].
6. Verify the **DOSE UNITS FOR DRUG** screen is displayed *(see Figure 1-7)*.
7. Using [PAGE UP] and [PAGE DOWN], select the desired dose units, and press [CHOOSE].
8. Verify the **CONC UNITS FOR DRUG** screen is displayed *(see Figure 1-8)*.
9. Select the desired **Drug Conc in Container**, and press [CHOOSE].
10. Verify the **DEFAULT UNITS/DRUG** screen is displayed.
11. Repeat step 6 through step 10 for each desired drug.
12. If there no other changes, press [CANCEL/BACK] to return to the main biomed settings screen, or turn off the infuser.

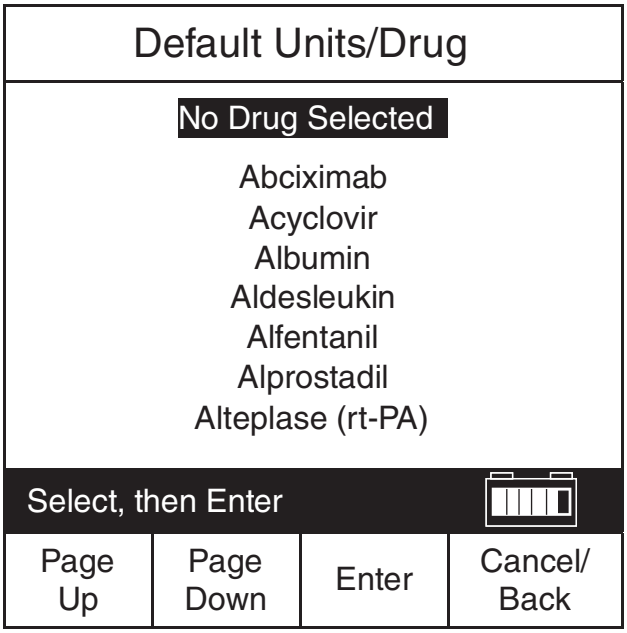

Figure 1-6. Default Units/Drug

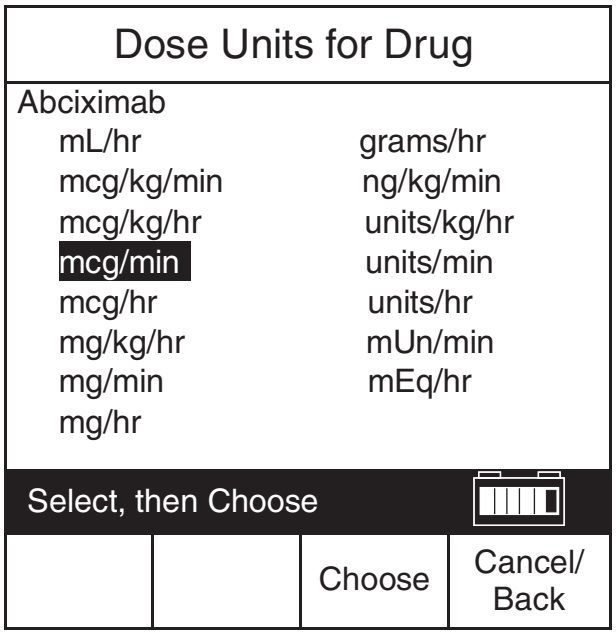

Figure 1-7. Dose Units for Drug

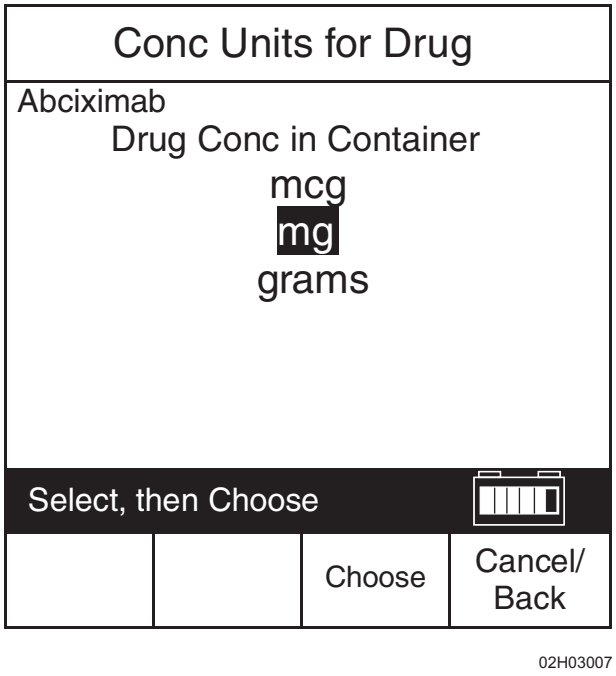

Figure 1-8. Conc Units for Drug

1.8.1.3
MACRO IV PARAMETERS

To review or change the macro IV parameters, see *Figure 1-9*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Access the IV parameters screen as described in *Section 1.8.1*.
3. Select **Macro IV Parameters**, and press [CHOOSE].
4. Verify the **MACRO IV PARAMETERS** screen is displayed *(see Figure 1-9)*.
5. Select the parameter to be changed.
6. Enter the desired value for the parameter selected.
7. Repeat step 5 and step 6 for each parameter to be changed.
8. If there are no other changes, press [CANCEL/BACK] to return to the IV parameters screen, or turn off the infuser.

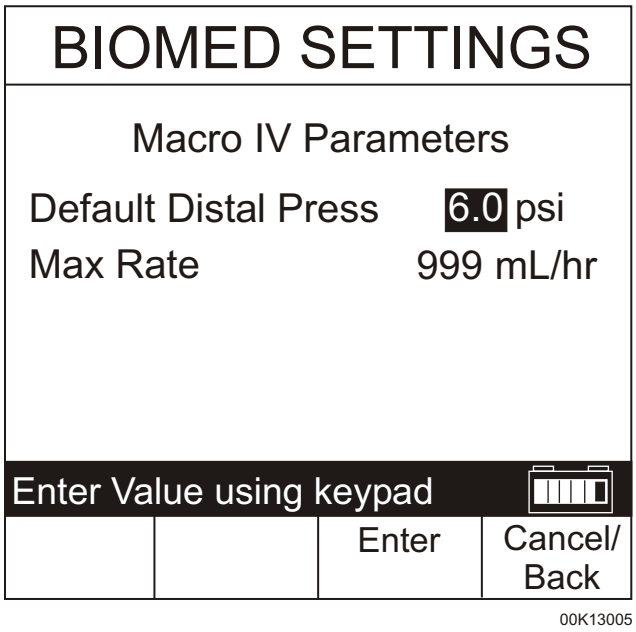

Figure 1-9. Macro IV Parameters

1.8.2
ALARMS LOG

Note: The alarms log will retain the latest 40 alarm and malfunction codes, listed in order from the most current to the oldest.

To view the alarms log, see *Figure 1-10*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Select **Alarms Log**, and press [CHOOSE].
3. Use the [PAGE UP] and [PAGE DOWN] softkeys to view the alarms log.
4. Press [BACK] to exit the alarms log and return to the main biomed settings screen.

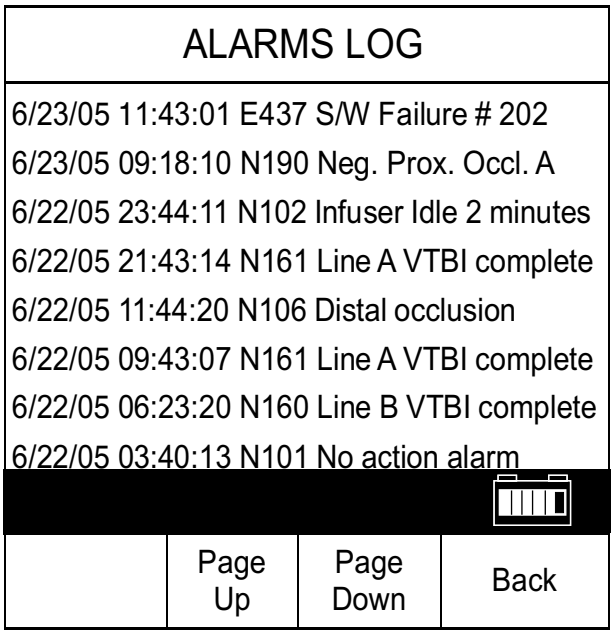
ALARMS LOG
6/23/05 11:43:01 E437 S/W Failure # 202
6/23/05 09:18:10 N190 Neg. Prox. Occl. A
6/22/05 23:44:11 N102 Infuser Idle 2 minutes
6/22/05 21:43:14 N161 Line A VTBI complete
6/22/05 11:44:20 N106 Distal occlusion
6/22/05 09:43:07 N161 Line A VTBI complete
6/22/05 06:23:20 N160 Line B VTBI complete
6/22/05 03:40:13 N101 No action alarm
Page Up
Page Down
Back
05K03008

Figure 1-10. Alarms Log

1.8.3
SETTING THE TIME AND DATE

Note: The infuser will automatically display February 29 on leap years.

Note: Daylight savings and time zone changes must be made manually.

To set the time and date, see *Figure 1-11*, then proceed as follows:

1. Access the biomed settings screen as described in *Section 1.8*.
2. Select **Set Time and Date**, and press [CHOOSE].
3. Select the parameter to be changed.
4. Enter the desired value.
5. Repeat step 3 and step 4 for each parameter to be changed.
6. Verify the time and date are correct, then press [ENTER] to return to the biomed settings screen.
7. If there are no other changes to the biomed settings, turn off the infuser.

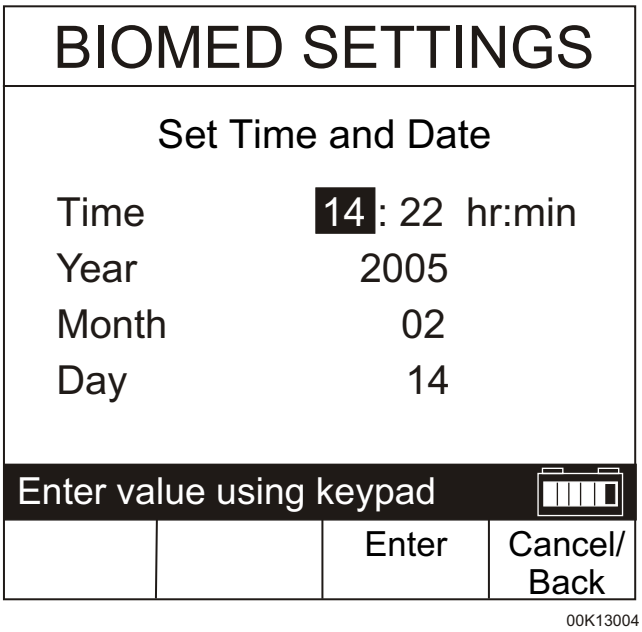

Figure 1-11. Setting the Time and Date

Section 2

WARRANTY

Subject to the terms and conditions herein, Hospira, Inc., herein referred to as Hospira, warrants that (a) the product shall conform to Hospira's standard specifications and be free from defects in material and workmanship under normal use and service for a period of one year after purchase, and (b) the replaceable battery shall be free from defects in material and workmanship under normal use and service for a period of 90 days after purchase. Hospira makes no other warranties, express or implied, as to merchantability, fitness for a particular purpose, or any other matter.

Purchaser's exclusive remedy shall be, at Hospira's option, the repair or replacement of the product. In no event shall Hospira's liability arising out of any cause whatsoever (whether such cause be based in contract, negligence, strict liability, other tort, or otherwise) exceed the price of such product, and in no event shall Hospira be liable for incidental, consequential, or special damages or losses or for lost business, revenues, or profits. Warranty product returned to Hospira must be properly packaged and sent freight prepaid.

The foregoing warranty shall be void in the event the product has been misused, damaged, altered, or used other than in accordance with product manuals so as, in Hospira's judgment, to affect its stability or reliability, or in the event the serial or lot number has been altered, effaced, or removed.

The foregoing warranty shall also be void in the event any person, including the Purchaser, performs or attempts to perform any major repair or other service on the product without having been trained by an authorized representative of Hospira and using Hospira documentation and approved spare parts. For purposes of the preceding sentence, "major repair or other service" means any repair or service other than the replacement of accessory items such as batteries, flow detectors, detachable AC power cords, and patient pendants.

In providing any parts for repair or service of the product, Hospira shall have no responsibility or liability for the actions or inactions of the person performing such repair or service, regardless of whether such person has been trained to perform such repair or service. It is understood and acknowledged that any person other than a Hospira representative performing repair or service is not an authorized agent of Hospira.

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Section 3

SYSTEM OPERATING MANUAL

A copy of the system operating manual is included with every Plum A+® infusion system. Insert a copy here for convenient reference. If a copy of the system operating manual is not available, contact Hospira Technical Support Operations *(see Section 6.1)*.

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Section 4

THEORY OF OPERATION

This section describes the Plum A+® theory of operation. The theory of operation details the general description, electronic subsystem overview, printed wiring assemblies, remote mounted peripherals, and mechanical overview of the infuser. Related drawings are provided in *Section 9*.

4.1 GENERAL DESCRIPTION

The infusion system includes the following features:

- Dose calculation
- Loading dose
- Multi-step programming
- Therapy selection
- Nurse call
- Delayed start setting
- Standby mode
- Drug label library
- Piggyback and concurrent delivery modes
- Titration
- 0.1-99.9 mL/hr flow rate range for both lines (in 0.1 mL/hr increments)
- 100-999 mL/hr flow rate range for both lines (in 1 mL/hr increments)
- Anti free-flow protection
- Air removal/backpriming
- Battery gauge
- Air detection (proximal and distal)
- Serial communication
- Alarm history
- Volumes infused (A, B, total volumes)
- KVO at dose end (1 mL/hr or less depending on delivery rate) or continue rate to continue
- Variable distal pressure setting
- Nonpulsatile volumetric accuracy
- Microprocessor control
- Large display
- Panel back illumination on mains power
- Lockout switch
- Standard fullfill, partfill, syringe, and vial use
- Enteral and parenteral fluid delivery
- Blood and blood product delivery
- Wide range of standard and specialty administration sets

Alarms include the following:

- Distal occlusion
- Proximal occlusion
- Proximal air-in-line
- Distal air-in-line
- Low battery
- Door open while pumping
- Lockout violation
- VTBI complete
- Valve/cassette test failure
- Nurse call
- No action alarm
- Infuser idle for two minutes

4.2
ELECTRONIC SUBSYSTEM OVERVIEW

This section describes the function and electronic circuitry of three main subsystems in the infuser: CPU subsystem, power supply subsystem, and mechanism subsystem. Schematic diagrams of subsystem PWAs are in *Section 9*.

Note: An asterisk (*) denotes an active low or negative true logic signal.

4.2.1
CPU SUBSYSTEM

The CPU subsystem contains the main microcontroller, which is responsible for controlling the display/keypad interface, external communications interfaces, and system management.

The CPU subsystem provides the following functions:

- External memory devices access
- LCD interfaces
- Real-time clock generator interface
- System watchdog
- Analog-to-digital and digital-to-analog converter interface
- Keypad interfaces
- Control and monitor status signals, such as LEDs, audible alarms, volume control, nurse call switch, and lockout switch
- Serial communication with host computer (DataPort)
- Power supply subsystem interface
- Mechanism subsystem interface

4.2.1.1
CPU

The central processing unit (CPU) is a Motorola MC68302. The CPU has a closely coupled 16 bit data bus and 24 bit address bus; MC68000 microprocessor core; a system integration block for peripherals; and an RISC communications processor. The MC68302 is packaged in a 144 pin thin quad flat pack (TQFP) package and operates from a 3.3 V_{DC} power supply. The on-chip peripheral devices are isolated from the system through the dual port RAM. The 1152 byte dual port RAM has 576 bytes of system RAM and 576 bytes of parameter RAM, which contains various peripheral registers, parameters, and the buffer descriptors for each of the three serial communication controller (SCC) channels and the serial communication port (SCP) channels. The 24 bit address bus is capable of accessing up to 16 MB of data.

4.2.1.2
SYSTEM MEMORY ADDRESS MAP

The CPU has a 24 bit address bus when combined with UDS*/A0. The address bus is a bi-directional, three state bus capable of addressing 16 MB of data that is configured as 16 bits per word (including the IMP internal address space). Each of the four programmable chip-select lines has two registers that define the starting address of a particular address space and the block size.

4.2.1.3
PROGRAMMABLE READ-ONLY MEMORY

The CPU subsystem has two 512 K x 8 bit programmable read-only memory (PROM) memory devices, which provide a total of 1024 KB. The PROM space is expandable up to 2 MB. The PROM memory devices operate off the 3.3 V_{DC} supply. The CPU chip-select 0 pin (CS0*), is connected to the PROM chip-enable (CE*) pin (signal CSROM*). This special chip-select signal can support bootstrap operation after reset. The interface to the CPU is the 16 bit data bus, and a 19 bit address bus. The address bus is connected to the ADDR<19:1> lines, and the data bus is connected to the DATA<15:0> lines.

4.2.1.4
STATIC RANDOM ACCESS MEMORY

There are two 512 K x 8 bit CMOS static random access memory (SRAM) devices, which provide a total of 1024 KB of data memory. During an SRAM read or write cycle, the chip-enable (CE*) is controlled by the CPU chip-select pin 1 (CS1*, signal name (CSRAM*)). The SRAM space is expandable up to 2 MB. The SRAM operates off the 3.3 V_{DC} supply. The CPU subsystem includes the additional SRAM for video buffer and real-time clock.

4.2.1.5
CONTROL LOGIC

The CPU PWA uses field programmable gate arrays (FPGA), which are high density, high speed, I/O intensive general purpose devices. They are used to implement all the digital control functions, including: memory-map address decoding; memory read-write enable; direct memory access (DMA) request; I/O status signals; chip-select control; motor control; sensor select; and power up/system reset control.

4.2.1.6
LCD CONTROLLER

The liquid crystal display (LCD) controller is used to interface the LCD to the CPU. The device displays layered text and graphics, scrolls the display in any direction, and partitions the display into multiple screens. It stores bit-mapped graphic data in external frame buffer memory. The display controller functions include: transferring data from the controlling microprocessor to the buffer memory, reading memory data, converting data to display pixels, and generating timing signals for the buffer memory and LCD panel. The LCD controller accesses 32 KB of frame buffer SRAM (video) via the controller's video address and data busses (VA<14:0> and VD<7:0>). The LCD controller external clock frequency is 8 MHz. The LCD controller and the display memory are operated off the 3.3 V_{DC} supply. The output signal levels are shifted up to 5 V_{DC} by buffers for interface with the 5 V_{DC} LCD panel.

The interface to the CPU is through the lower 8 bits of the data bus, which is connected to DATA<7:0> lines, address line A1, and LCD chip-select signal CSLCD* (CS2*). This controller is also configured as 8080 family compatible interface device with all the control signals, such as WRLCD* (WR*) and RDLCD* (RD*), generated by the FPGA logic.

4.2.1.7
LCD BACKLIGHT CONTROL

The LCD panel is backlit by a cold cathode fluorescent tube (CCFT) lamp. The CCFT lamp requires 300 V_{rms} to operate; a current controlled DC-to-AC voltage inverter circuit is used to deliver a current regulated sine wave to the lamp. A switching regulator regulates the CCFT current by monitoring feedback pin 3, and varies its output duty cycle to drive a DC/AC inverter. Intensity control is achieved by superimposing a DC control signal with the feedback signal. The DC control signal is sourced by a voltage divider consisting of a digitally controlled non-volatile potentiometer and three series diodes.

The CPU can adjust LCD backlight intensity by selecting the digitally controlled non-volatile potentiometer and controlling TUBU/D and TUBINC* signals. The potentiometer has a five bit up/down counter with non-volatile memory. It is used to store one of 31 settings of the potentiometer. Each count represents 323 Ω with a range of 323 to 10 KΩ The current counter value is stored in non-volatile memory after CSTUB* is returned high while the TUBINC* input is also high. The current counter value is not stored if CSTUB* is returned high and TUBINC* is low. The CCFT intensity is directly proportional to the CCFT current, where 0 mA_{rms} is minimum intensity and 5 mA_{rms} is maximum intensity. The CCFT current is inversely proportional to the counter value.

4.2.1.8
LCD CONTRAST CONTROL

A digitally adjustable LCD bias supply is used to control the LCD contrast over a range of -24 to -8 V_{DC}. It is digitally adjustable in 64 equal steps by an internal digital-to-analog converter (DAC). The CPU provides two signals, LCDADJ (ADJ) and LCDCTL (CTL), to interface with this device. On power up or after a reset, the counter sets the DAC output to the mid-range value. Each rising edge of LCDADJ increments the DAC output. When incremented beyond full scale, the counter rolls over and sets the DAC to the minimum value. Therefore, a single pulse applied to LCDADJ increases the DAC set point by one step, and 63 pulses decrease the set point by one step.

4.2.1.9
REAL-TIME CLOCK

The watchdog timekeeper chip includes a complete real-time clock/calendar (RTC), watchdog timer, alarm, and interval timer. The time/date information includes hundredths of seconds, seconds, minutes, hours, date, month, and year. The date at the end of the month is automatically adjusted for months with less than 31 days, including correction for leap year. The watchdog timekeeper operates in either 24-hour or 12-hour format with an AM/PM indicator. The device can be programmed to set up an interval timer, and it can generate an alarm every day, hour, or minute. These alarm functions may be used to schedule real-time related activities. A parallel resonant 32,768 Hz crystal oscillator drives the internal time base.

The external interface is a separate (non-multiplexed) 8 bit data bus and 6 bit address bus, with a contiguous address space of 64 bytes. When system power is turned off, a battery voltage input is available, which makes the RTC data non-volatile. The address bus is connected to the ADDR<6:1> lines, and the data bus is connected to DATA<7:0> lines. Since the CPU accesses are 16 bits wide, the RTC data is on the lower byte of the word. The RTC chip-enable pin (CE*) is active low enabled for read and write operations. It is driven by the FPGA control logic, chip-select RTC signal (CSRTC*), which involves address decoding circuitry.

4.2.1.10
VOLTAGE MONITOR WATCHDOG TIMER

It is important to protect the system during power transitions, and the CPU is reset after the V_{CC} power supply is applied. The microprocessor supervisory circuit generates an automatic reset output during power up, power down, or brownout conditions. When the V_{CC} falls below the reset threshold voltage of 2.9 V_{DC}, the reset signal (RESET*) goes low and holds the microprocessor in reset for approximately 200 ms after V_{CC} rises above the threshold. The supervisory circuit includes a chip-select inhibit circuit, which is used to disable access to the real-time clock's non-volatile SRAM during power transitions and power down mode.

This device also provides a watchdog timer function to monitor the activity of the microprocessor. To service the watchdog timer immediately after reset, the device has a longer time-out period (1.6 second minimum) right after a reset. The normal time-out period (70 ms minimum) is effective after the first transition of watchdog input (WDI) after RESET* is inactive. If the microprocessor does not toggle WDI within the time-out period, both RESET* and watchdog out (WDO*) outputs are asserted low. The RESET* remains active low for a minimum of 140 ms and it resets the CPU. The WDO* remains low as long as the WDI remains either high or low for longer than the watchdog time-out period. After a reset, the software reads this memory-mapped bit to determine if the latest reset was a watchdog time-out.

4.2.1.11
ANALOG-TO-DIGITAL CONVERTER

The analog-to-digital converter (ADC) monitors the proximal pressure sensor, distal pressure sensor, proximal air sensor, distal air sensor, battery charge/discharge current, battery voltage, buzzer test signal, LCD contrast voltage, CCFT test signal, and two chopper motor drive reference voltages. The ADC is an advanced 10 bit accurate, 11 channel, switched-capacitor, successive-approximation device. It has three inputs and a three-state output (chip-select, I/O clock, address input, and data out) that provide a direct four-wire interface to the serial communication port of the CPU. The ADC is designed to be used in conjunction with multiple serial devices on a common bus; consequently, the data-out pin is driven only when the chip-select (CS*) pin is asserted. *Figure 4-1* illustrates the serial interface between the ADC and the CPU.

In addition to a high-speed ADC and versatile control capability, this device has an on-chip 14 channel multiplexer that can select any one of 11 analog inputs or any one of three internal self test voltages. The sample-and-hold function is automatic. The end-of-conversion (EOC) output goes high to indicate that conversion is complete. The CPU polls the EOC signal.

Channel selection and conversion results are transferred through the SCP pins. A serial transfer synchronizing clock (SPCLK) must be fed into the I/O clock input pin when the CS* pin is driven low. The address to be converted is serially transmitted into the address pin, and the conversion results are serially shifted out the data-out pin. Typical access time is 21 microseconds. The APP PWA is the source of the 2.5 V_{DC} reference voltage. The analog inputs are selected by the channel multiplexer according to the input address *(see Table 4-1)*. The input multiplexer is a break-before-make type to reduce input-to-input noise injection resulting from channel switching.

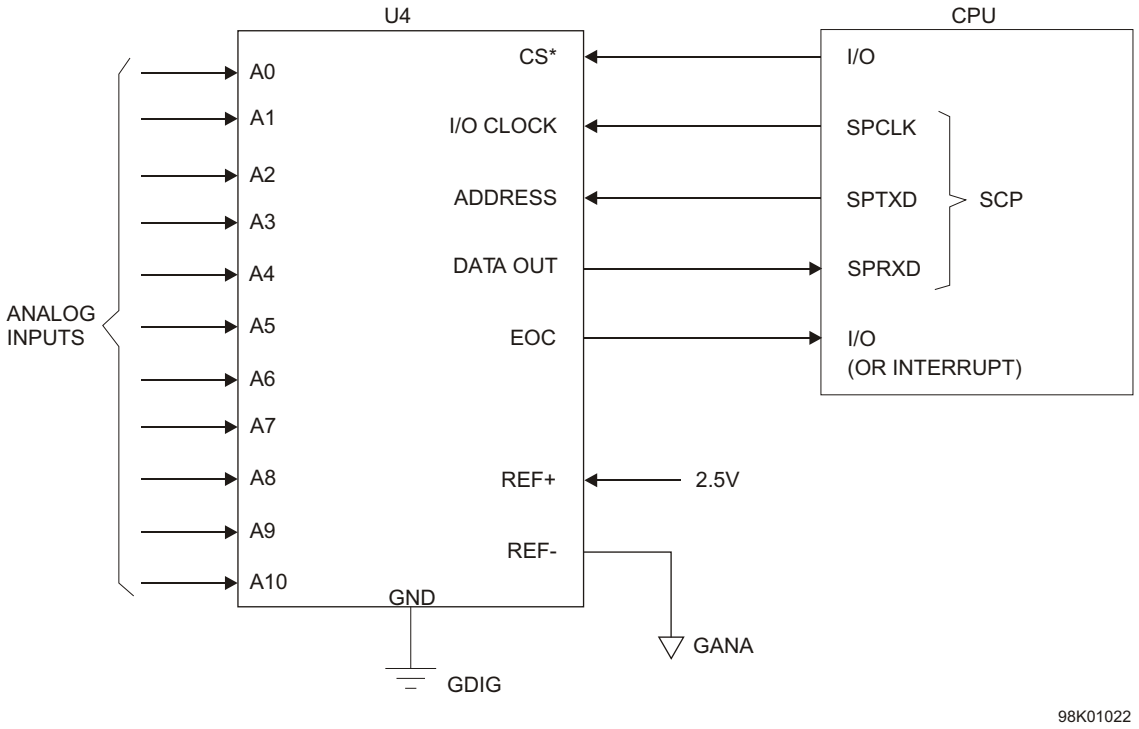

Figure 4-1. Serial Interface to ADC

Table 4-1. Analog Inputs			
Signal Name	**Analog Input**	**Address (hex)**	**Description**
PRPRS	A0	$00	Proximal pressure sensor
DIPRS	A1	$01	Distal pressure sensor
PXAIR	A2	$02	Proximal air sensor
DIAIR	A3	$03	Distal air sensor
IBATT	A4	$04	Battery current
VBATT	A5	$05	Battery voltage
BUZTST	A6	$06	Buzzer test voltage
LCDTST	A7	$07	LCD contrast test voltage
TUBTST	A8	$08	CCFT intensity test voltage
MI_STA	A9	$09	Motor current A control
MI_STB	A10	$0A	Motor current B control
		$0B	$(V_{ref(+)} - V_{ref(-)}) / 2$
		$0C	$V_{ref(-)}$
		$0D	$V_{ref(+)}$

4.2.1.12
DIGITAL-TO-ANALOG CONVERTER

The dual 8 bit digital-to-analog converter (DAC) generates two analog signals to control the phase A and phase B motor coil currents. The interface between the DAC device and the CPU is the 8 bit data bus, which is connected to DATA15:8. All the control signals for this DAC are generated by FPGA logic devices. Buffer amplifier/ground compensation circuits condition the DAC outputs.

4.2.1.13
FRONT PANEL KEYPAD MATRIX

A 5 x 5 membrane switch keypad matrix is located on the front panel. The keypad column lines (COL4:0) are driven by open collector type memory mapped input ports, while the keypad row lines (ROW4:0), are read by memory mapped input ports *(see Table 4-2)*. The keypad strobing, scanning, and switch de-bouncing is accomplished by software. The keypad interface is designed with ESD protection.

Table 4-2. Keypad Map

	COL 0	COL 1	COL 2	COL 3	COL 4
Row 4	Softkey 1	Softkey 2	Softkey 3	Softkey 4	
Row 3	START	1	2	3	[▲]
Row 2	STOP	4	5	6	
Row 1	Charge/Line Indicator	7	8	9	[▼]
Row 0	ON/OFF	CLEAR	0	.	SILENCE

4.2.1.14
FRONT PANEL [ON/OFF] KEY

The [ON/OFF] key on the front panel provides a start up (STRTUP) signal to wake up the power supply when the system is shutdown. When activated during normal operation, the [ON/OFF] key interrupts (STRUPD*) the CPU, signaling a request for shutdown.

4.2.1.15
FRONT PANEL LED INDICATORS

The CPU drives the three light emitting diode (LED) indicators embedded in the front panel. Two memory mapped I/O signals activate the two LED lights used to indicate which channel is in delivery mode (LEDAE*, LEDBE*). The AC power on LED indicates the status of AC power (LEDAC) and that the system is in the battery charge mode. A buffered AC on signal (BACON) drives the LED and is active only when AC power is present.

4.2.1.16
KEYPAD LOCKOUT INTERFACE

A lockout switch (SW1) on the peripheral PWA indicates the front panel keypad is locked. A memory mapped input port (LOTSW*) reads the switch. The switch serves as a lockout request and software performs the lockout.

4.2.1.17
NURSE CALL INTERFACE

A nurse call relay switch on the peripheral PWA indicates alarm conditions to a remote operator. A memory-mapped output signal (NURSE) activates the relay during alarm conditions. The relay has both normally open and normally closed contacts. A jumper on the peripheral board selects the contact type. The factory setting is normally open.

4.2.1.18
AUDIBLE INDICATORS

There are two audible indicators on the CPU subsystem. A loud, main audible indicator is mounted on the main chassis. This main alarm is used for alerting the operator to alarm conditions. A keypad beeper (LS1), with lower power and a distinctly different tone, is used to provide audible feedback to the operator. The keypad beeper is driven by a memory-mapped output (KEYALM). It is used to indicate keypad activation, and confirmation to the operator.

The main alarm has an adjustable volume control on the peripheral PWA, mounted on the rear of the device. The main alarm can be activated by either a memory-mapped control (MAINALM), the reset pulse(s), or by a power failure alarm latch. The main alarm will sound a chirp for every reset pulse sent by the watchdog timer IC. Continuous chirping indicates a stuck processor.

The alarm is activated continuously during power failure. If the control software does not shut down power in a proper sequence, a latch on the CPU PWA, powered by a backup supply (0.1 F supercap), will activate a continuous alarm. This continuous alarm sounds until either the backup supply is discharged or the user resets the latch by pressing the front panel [ON/OFF] key. Reliable operation of the main alarm is assured by software monitoring of a buzzer test signal (FBUZTST) via the ADC.

4.2.1.19
BARCODE READER INTERFACE

✎ **Note:** The barcode reader feature will not be present on later versions of the Plum A+®.

The CPU communicates with a barcode wand that is connected to the peripheral PWA from the rear of the infuser. The barcode wand reads and decodes a Code 128 barcode symbology and outputs the barcode data via an RS-232 port using an asynchronous, serial ASCII format. The software controls power to the barcode reader and to the interface circuits via memory-mapped outputs BARPWR and COMPWR*. The barcode reader is isolated from the main system by an optical data path on the peripheral PWA and an isolated power supply.

4.2.1.20
DATAPORT INTERFACE

The CPU communicates with an external computer by way of a DataPort interface. The DataPort interface provides for remote monitoring of up to 15 infusers using a host computer with a modified RS-232-D serial interface. Infusers are either connected directly to the host or in a daisy chain configuration using junction boxes that provide a 5 bit hard ID via DIP switches on the junction box. The DIP switches are buffered (peripheral PWA U8) and read by the CPU via the memory-mapped input/output (MMIO) port.

The DataPort system conforms to the EIA-232-D standard, with the following exceptions:

- DataPort uses non-standard DB-15 and 6 pin modular connectors in addition to the standard DB-25 and DB-9 connectors
- With DataPort, more than one infuser is allowed on the line
- The minimum line impedance is 2 KΩ (EIA-232-D standard: 3 KΩ min.)
- The maximum line impedance is 30 KΩ (EIA-232-D standard: 7 KΩ max.)
- The maximum line capacitance is 13 nF (EIA-232-D standard: 2,500 pF)

The communications default is 1200 BAUD, no parity, 8 data bits and 1 stop bit. The BAUD rate is selectable (1200, 2400, 4800, and 9600). The data format on the serial port is a 10 bit frame with asynchronous start and stop. The CTS line is held high and the RTS line is disconnected.

The DataPort is isolated from the main system by an optical data path on the peripheral PWA and an isolated power supply.

4.2.1.21
POWER SUPPLY INTERFACE

The CPU subsystem interfaces the power supply subsystem by providing the MMIO signals needed for power control and battery management. Additionally, the CPU subsystem measures the battery terminal voltage and charge/discharge current via the ADC.

See *Table 4-3* for CPU-power supply interface signals.

Table 4-3. CPU-Power Supply Interface

Signal Name	Type	Description
PWRHLD	D, O	Holds system power on
STRTUP	A, I	Startup pulse from the [ON/OFF] key
STRUPD*	D, I	Digital startup pulse, used as interrupt to the CPU
V3_3	P	3.3 V system power
V5_0/VANA	P	5 V analog and interface power
VMOT	P	Raw, unregulated charger voltage or battery voltage
V2_7	P	2.7 V backup power for RTC and non-volatile SRAM
VSC	P	Full time 5 V supply, backed up by supercap

Table 4-3. CPU-Power Supply Interface		
Signal Name	**Type**	**Description**
V12_0	P	12 V, low current supply for audio alarm
OVRVLT*	D, I	Signal that indicates overvoltage, regulation problem on the power supply main regulator
BACON	D, I	Buffered AC on signal
IBATT	A, I	Voltage proportional to integration of battery charge/discharge current
VBATT	A, I	Divided battery terminal voltage
CHG*	D, O	Battery charger enable
VFLOAT*	D, O	Set the main regulator voltage to battery float charge level
ITGRST	D, O	Reset the charge current integrator

Legend: P = Power; A = Analog; D = Digital; I = Input; O = Output

4.2.1.22
MECHANISM INTERFACE

The CPU subsystem provides the MMIO ports for interface to the mechanism subsystem, in addition to the analog interface mentioned in *Section 4.2.1.11* and *Section 4.2.1.12*.

See *Table 4-4* for CPU-mechanism interface signals.

Table 4-4. CPU-Mechanism Interface Signals		
Signal Name	**Type**	**Description**
MI_STA	A, O	Motor current set for phase A
MI_STB	A, O	Motor current set for phase B
GDAC	A, O	Ground signal from chopper (for compensation)
M_PHA	D, O	Motor phase A
M_PHB	D, O	Motor phase B
M_SEL1, M_SEL0	D, O	Motor select bits
FLCAME	D, O	I/O and L/S cam flag sensors enable
FLPINE	D, O	L/S pin motion detectors enable
FLPLE	D, O	Plunger motor sensor pair enable
FLLS_C	D, I	Flag, L/S valve cam sensor
FLIO_C	D, I	Flag, I/O valve cam sensor
FLLS_A	D, I	Flag, L/S valve A pin detector
FLLS_B	D, I	Flag, L/S valve B pin detector

Table 4-4. CPU-Mechanism Interface Signals		
Signal Name	**Type**	**Description**
FLPLRO	D, I	Flag, plunger rotation sensor
FLPLTR	D, I	Flag, plunger translation sensor
PXPRE	D,O	Proximal pressure sensor enable
PXPRS	A, I	Proximal pressure sensor
DIPRE	D, O	Distal pressure sensor enable
DIPRS	D, O	Distal pressure sensor
PXARE	D, O	Proximal air sensor enable
PXAIR	A, I	Proximal air sensor
DIARE	D, O	Distal air sensor enable
DIAIR	A, I	Distal air sensor
CASPR*	D, I	Cassette present
CASS2*, CASS1*, CASSO*	D, I	Cassette type coding: Macro (111), Micro (010); all others are invalid
SPCLK	D, O	SCP clock output
SPRXD	D, I	SCP receive data
SPTXD	D, O	SCP transmit data
CSSEP*	D, O	Chip select, EEPROM
V5_0	P	5 V supply for interface power
V3_3	P	3.3 V supply for logic power
GDIG	P	Digital ground
VANA	P	5 V supply for analog power
GANA	P	Analog ground
VMOT, GMOT	P	Motor power is directly from power supply PWA
V2_5	A, I	Reference voltage for ADC and DAC

Legend: P = Power; A = Analog; D = Digital; I = Input; O = Output

4.2.2
POWER SUPPLY SUBSYSTEM

The power supply subsystem provides DC power to system circuits and interface software controlled power and battery management.

The power supply subsystem provides for the following functions:

- Main switching regulator
- AC power detection
- Main regulator fault detection
- System power (secondary regulators)
- Auxiliary supplies
- Power control
- Battery charging circuitry
- Battery terminal voltage measurement
- Battery charge/discharge current measurement

4.2.2.1
MAIN SWITCHING REGULATOR

The main source of power for the infuser is the AC line. The main switching regulator is a pulse width modulated, AC-to-DC converter which provides the system an isolated DC voltage of 6.74 V_{DC} (or 7.35 V_{DC} in battery charger boost mode). The main regulator is preceded by: line fuses F1 and F2, surge suppressor VR1, and a line filter. The bridge rectifier U14 and capacitors C52 and C53 provide the DC voltage required for the switching circuit. Voltage regulator U13 provides the pulse width modulator (PWM) device U12 startup supply voltage. After startup, supply voltage for U12 is supplied by half wave rectifier circuitry CR14, R76, and C51.

The PWM oscillation frequency is approximately 40 kHz, determined by external resistor R72 and capacitor C45. U12 controls the power delivered by varying the duty cycle of the power metal-oxide-semiconductor field-effect transistor (MOSFET) Q9, which drives T2. A half-wave rectifier rectifies the transformer's secondary voltage, which provides the raw DC voltage for the battery charger and system power. There are three feedback mechanisms that maintain control: a main loop for normal control, a secondary loop for overvoltage protection, and a current limit loop.

4.2.2.1.1
Main Loop

The main loop uses an optical feedback path to regulate the charger voltage (BATPOS) at 6.9 V_{DC} (except during boost charge, when the limit is raised to 7.5 V_{DC} by software control of the VFLOAT* line). A shunt regulator and opto-isolator provide feedback to the PWM error amplifier.

4.2.2.1.2
Secondary Loop

Diode CR10 and opto-isolator U10 provide overvoltage protection. CR10 conducts and activates U10 when secondary voltage exceeds approximately 10 V_{DC}. The duty cycle of U12 is reduced until the excessive voltage is removed.

4.2.2.1.3
Current Limit Loop

The current limit loop is activated when the primary current, sensed by R71, exceeds 3 A. Resistor R70 and capacitor C46 filter the voltage across R71 and feed it back to the current sense input (1.5 V_{DC} threshold) of U12. The duty cycle of U12 is reduced until the excessive load is removed.

4.2.2.2
MAIN REGULATOR FAULT DETECTION

If the switching regulator's main loop fails, the secondary voltage limit loop takes over. However, the battery charger and motors must be disabled, and an alarm must be generated. A comparator is used to monitor the raw DC (+BUSS) for overvoltage. A 3.3 V_{DC} logic signal (OVRVLT*) is provided to the CPU subsystem.

4.2.2.3
SYSTEM POWER

Along with the unregulated VMOT supply, a secondary switching regulator provides system power. The secondary switching regulator includes IC U4, transformer T1, and transistors Q4 and Q5. The regulator is a triple output, wide supply range, fly-back converter that provides regulated 3.3 V_{DC}, 5 V_{DC}, and 12 V_{DC} outputs from the five winding transformer T1. The regulator operates over an input range of 4 to 10 V_{DC} and provides output current limit as well as voltage overshoot limit. Primary feedback is metered through a bias arrangement on transistor Q3. A Schottky rectifier diode CR4 provides feedback in the event of V3_3 or V12_0 failure, and transistor Q10 provides feedback in the event of V5_0 failure. The positive terminal of the battery provides the raw DC voltage, VMOT, for the motors and backlight of the display.

4.2.2.4
AUXILIARY SUPPLIES

The power supply subsystem provides full time 5 VDC and 2.7 V_{DC} supplies, which are active when battery or AC voltage is present. The full time 5 V_{DC} supply (VSC) uses a linear low dropout voltage regulator U6, whose power source is directly from the battery and is backed up by a 0.1 F capacitor. VSC is used for the ON/OFF switch and a power failure alarm latch. The full time 2.7 V_{DC} supply (V2_7) is derived from VSC and is used to supply the ultra-low current needed to power the real-time clock and non-volatile SRAM during shutdown.

4.2.2.5
POWER CONTROL

The infuser will operate in one of three modes: normal, standby, or shutdown. During normal operation, the user interface is active and either on battery or AC line power. During standby mode the user interface is inactive while the CPU is still operating, servicing the battery management and waiting for a startup interrupt. Shutdown mode is when system power is off. Shutdown mode only occurs during battery operation; otherwise, +BUSS holds the system power on.

The infuser is activated when the [ON/OFF] key is pressed or the AC line is plugged in. The [ON/OFF] key activates the STRTUP signal, triggering a three second one-shot circuit (C3, R10, CR1, and Q1) that will temporarily turn the system power on. This three second one-shot period allows the CPU enough time to power up, initialize, and turn on the PWRHLD signal. The CPU monitors the STRTUP signal, via interrupt, to signal a user request for turning off the infuser.

Figure 4-2 illustrates the system startup/shutdown sequence while battery powered. System power is always on while AC powered.

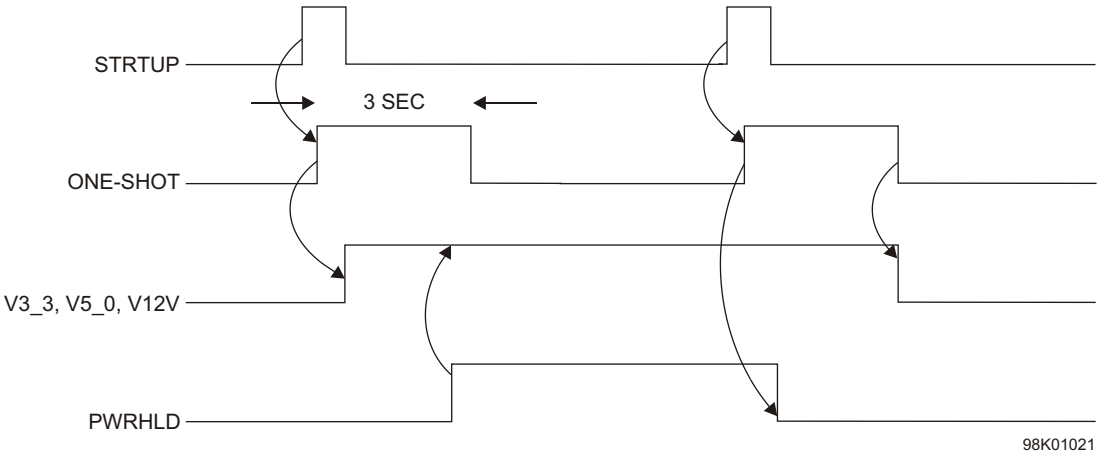

Figure 4-2. System Startup and Shutdown Timing, Battery Powered

4.2.2.6
BATTERY VOLTAGE MEASUREMENT

The battery terminal voltage (BATPOS - BATNEG) is measured with a differential amplifier consisting of U1, R1, R2, R4, R7, and R8. It has a gain of 0.317 to generate a single ended VBATT signal. The VBATT signal is then provided to the CPU A/D converter as input for the battery management algorithms.

4.2.2.7
BATTERY CHARGE/DISCHARGE CURRENT MEASUREMENT

The battery management algorithms measure battery charge/discharge current for battery capacity estimation and charger control. The charge/discharge current is measured by integrating the voltage across current sense resistor R57. An operational amplifier (op-amp) integrator circuit, consisting of U2, C5, R12, R13, R19, and R20, provides a voltage proportional to the integration of battery current (IBATT) over a CPU controlled measurement period. The IBATT signal is fed to the CPU A/D converter, where it is sampled at the end of the measurement period. The battery management algorithm further accumulates the charge/discharge current for battery capacity estimation. The op-amp integrator is reset by the CPU system at the beginning of each measurement period by parallel analog switches U3, controlled by the CPU's ITGRST signal. The battery management algorithm periodically calibrates the op-amp integrator.

4.2.2.8
BATTERY CHARGER

The software battery management algorithm controls the battery charger. The charging scheme is a current limit/two stage voltage limit charger. The charge current is limited to 1.3 A and the voltage is limited to either 6.74 V_{DC} or 7.35 V_{DC}.

The source of the charge current is power MOSFET transistor Q7 operating in the linear mode. Charge current passes through a current sense resistor R57, where it develops a feedback signal for the charger control amplifier consisting of U7, Q6, and associated parts. The feedback signal is compared against a 2.5 V_{DC} voltage reference U8. A 0.5 A fuse protects against damage due to a short circuit. The battery management algorithm maintains on/off control of the charger by the charger enable signal CHG*. When set high, CHG* activates a comparator, which overrides the feedback signal and disables the charger. Excessive voltage on the BATNEG terminal indicates that there is a shorted battery cell, and will disable the charger through the same comparator.

4.2.3
MECHANISM SUBSYSTEM

The mechanism subsystem includes the electronics and electromechanical components that interface with the infuser pumping mechanism.

The mechanism subsystem provides the following functions:

- Chopper motor drive for three stepper motors (plunger, L/S valve, I/O valve)
- Four motor position sensors (flag detectors)
- Precision voltage reference
- Two air sensors (distal, proximal)
- Two pressure sensors (distal, proximal)
- Cassette presence and type detection
- Serial electrically erasable PROM (EEPROM)

See *Table 4-4* for mechanism interface signals.

4.2.3.1
MOTORS/MOTOR DRIVE

The infuser uses three stepper motors for pumping: one for fluid displacement and two for cassette valve actuation. The stepper motors are driven, under step-by-step control from software, by a unipolar chopper drive.

4.2.3.1.1
Stepper Motors

Each motor is named by its function, as follows:

- Plunger motor for driving the plunger screw
- I/O valve motor for moving the input-output valve pins
- L/S valve motor for moving the line select valve pins A and B

All three motors are four phase stepper types. One electrical revolution is accomplished after four motor steps (phases) are completed. The step-angle (the number of steps per shaft revolution) resolutions are 3.6° /step (100 steps/rev) for the plunger motor, and 7.5° /step (48 steps/rev) for the I/O and L/S valve motors.

The unipolar motor windings have a center tap connected on each of the two coils as shown in *Figure 4-3*. Unidirectional current enters the center tap and is steered to one end of the coil or the other end by the driver electronics, creating positive or negative flux lines in the motor coil. With two coils each with a choice of flux polarity, four electrical combinations or phases are possible.

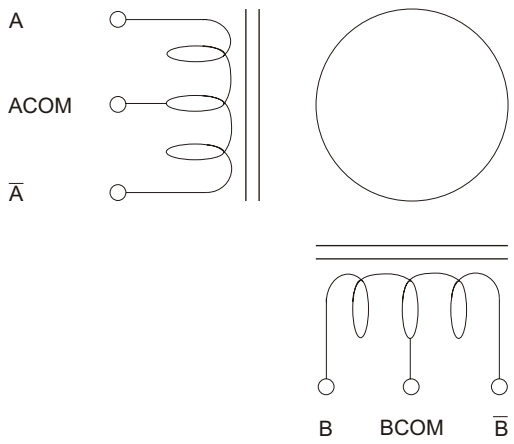

Figure 4-3. Stepper Motor Coils

4.2.3.1.2
Chopper Motor Drive

The infuser stepper motor drive is a chopper drive, which is a pulse width modulation of the coil current in each motor winding. Current is switched on and off to maintain a predetermined coil current independent of supply voltage and motor speed. The motor winding inductance acts as a filter to smooth out the switching currents, slowing the current rise when turned on and storing a decaying current when turned off. Each motor coil is modulated independently, allowing different coil currents in the two motor windings. The coil current is sensed and compared to a reference input for each winding. Modulation circuits correct for any error between the sensed current and the reference. This reference input can be changed to set a different coil current.

4.2.3.2
MOTOR POSITION SENSORS

Motor position is estimated by counting the motor steps, relative to a position reference. Optical switches and flags serve as position references, which are used to find the motor home positions and to verify proper motion. Flag positions are anticipated by software.

Optical switch flag sensors are used for tracking the following:

- Plunger motor rotational position (coupler flag)
- Plunger translational (linear) position
- I/O valve motor rotational position (cam flag)
- L/S valve motor rotational position (cam flag)

Each optical switch consists of an infrared LED, which shines through a rectangular aperture, across a slot, to illuminate a photo-transistor. The photo-transistor is activated as long as the beam is on and not blocked (by a flag in the slot). The optical switches are distributed throughout the mechanism, near their associated flags. The motor rotational optical switches are mounted on the driver PWA along with the control circuitry. The plunger translational optical switch is mounted remotely on the switch PWA. The switches are used intermittently to save power.

There are two control signals that enable associated switch pairs, as follows:

- FLCAME flag valve motor cam sensor enable
- FLPLE flag plunger motor rotation and translation sensors enable

Each of these control signals enables a constant current source which turns on the associated switch's infrared LEDs. The photo transistor states are sensed by Schmidt trigger inverters on the driver PWA, which provide a 3.3 V logic high when the optical path is blocked or a logic low when the optical path is clear. The Schmidt trigger output is high when the sensor is disabled.

The following output signals are provided to the CPU subsystem:

- FLIO_C flag I/O valve motor cam sensor
- FLLS_C flag L/S valve motor cam sensor
- FLPLRO flag plunger motor rotation sensor
- FLPLTR flag plunger motor transition sensor

4.2.3.3
V2_5 REFERENCE VOLTAGE

A precision 2.5 V_{DC} reference voltage is generated on the APP PWA for use by the pressure sensor excitation circuits, the air sensor amplifier circuits, and the ADC and DAC reference voltage. The precision 2.5 V_{DC} reference is buffered by a voltage follower. The signal name is V2_5.

4.2.3.4
AIR SENSORS

The mechanism subsystem includes two air sensors, used to detect air passage into (proximal) or out of (distal) the cassette. Both sensors are piezoelectric crystal transmitter receiver pairs. Liquid between the transmitter and receiver will conduct the ultrasonic signal, while air will not *(see Figure 4-4)*.

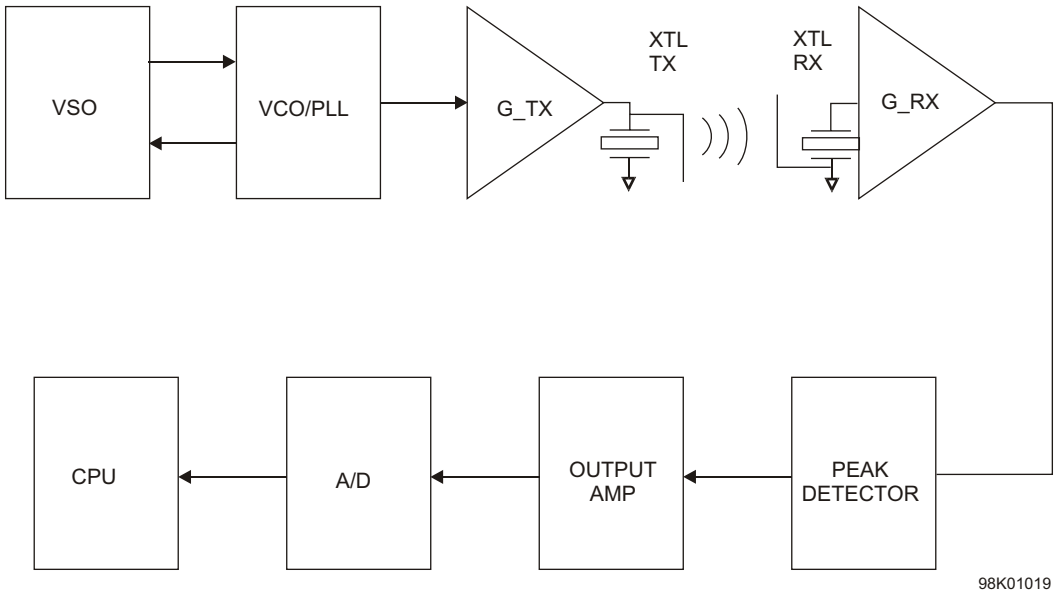

Figure 4-4. Air Sensor Block Diagram

4.2.3.4.1

Transmitter Circuitry

The transmitter circuitry consists of a voltage sweep oscillator (VSO), a voltage-controlled oscillator (VCO), and a transmitter amplifier, and are located on the APP PWA.

The voltage sweep oscillator circuit oscillates at approximately 12 kHz at 50 percent duty cycle. The output of the sweep oscillator is between +2 V_{DC} and +3 V_{DC}, and is used to sweep the VCO. The VCO sweeps through the sensor's peak coupling frequency, which is between 3 MHz and 6 MHz. A resistor and capacitor are used to configure the VCO center frequency. The VCO is enabled when the CPU asserts either DIARE or PXARE control signals.

The transmitter amplifier consists of a push-pull, emitter-follower, complementary pair of transistors. The transmitter amplifier drives both proximal and distal sensors simultaneously.

4.2.3.4.2

Receiver Circuitry

When the cassette's test port is filled with fluid, the transmitted signal will be coupled to an identical piezoelectric crystal, where it is amplified and detected by the receiver circuitry. The receiver circuitry consists of an amplifier, a peak detector, and an adjustable gain buffer stage. There is a separate, symmetrical receiver circuit for each channel (proximal and distal). Component references (called out in this design description) will be made to the distal channel only.

The first amplifier includes two, directly coupled common emitter stages, biased from the V2_5 supply. DIARE and PXARE are used to enable the distal and proximal sensors, respectively. The detector stage consists of an emitter follower, charging a 400 μsec time constant, refreshed every 40 microseconds (twice per VCO sweep).

The peak detector output is buffered by an op-amp configured as a basic non-inverting amplifier with a trimming potentiometer for gain adjustment. Each sensor has an independent gain adjustment. The two air sensor, gain-trimming potentiometers are accessible for calibration in an assembled mechanism.

The following final signals are read by the CPU subsystem via the ADC:

- PXAIR proximal air sensor output
- DIAIR distal air sensor output

4.2.3.5

PRESSURE SENSORS

The mechanism subsection contains two strain gauge-type pressure sensors, one at the proximal and the other at the distal cassette ports. Electrically, the strain gauge is a Wheatstone bridge made of four strain gauge resistors. When the bridge is electrically excited, the bridge will output a millivolt level signal proportional to the applied pressure. The output signal is amplified and offset adjusted before being read by the ADC. Each pressure sensor circuit includes an excitation voltage supply, sensor amplifiers, and a low pass filter.

The pressure sensor circuitry is on the APP PWA. Each of the two channels has an identical topology, but different gain and filter response. A block diagram of this circuit is shown in *Figure 4-5*.

Note: Component references are made to the distal channel only.

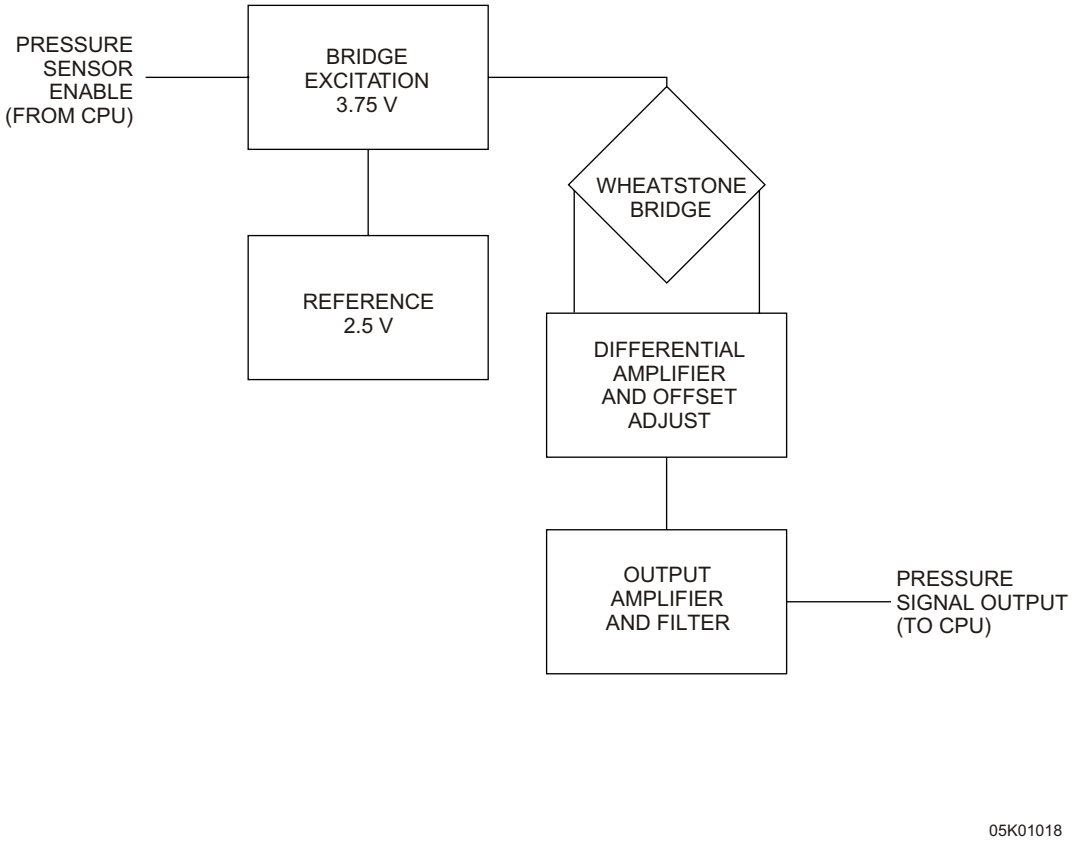

Figure 4-5. Pressure Sensor Excitation and Amplifier Block Diagram

4.2.3.5.1

Bridge Excitation Supply

The bridge excitation voltage is 3.75 V_{DC}, and is derived from the 2.5 V_{DC} reference signal (V2_5), gained 1.5 times by an amplifier. The CPU subsystem may independently enable power to each pressure sensor bridge.

The following enable signals are active high 3.3 V logic level inputs:

- PXPRE proximal pressure sensor enable
- DIPRE distal pressure sensor enable

4.2.3.5.2
Amplifier and Low Pass Filter

The pressure sensor amplifiers include a high gain differential pre-amplifier, followed by a second stage non-inverting amplifier with low gain. A trimming potentiometer is adjusted to minimize any offset in the impedance of the bridge.

A two-pole filter is used to filter the pressure signals. The first pole is formed by a capacitor (multiplied by 230 due to Miller effect) and a Thevenin resistance. The second pole is the RC filter at the ADC input, which is located on the CPU PWA.

The output signals to the A/D converter in the CPU PWA are, as follows:

- PXPRS proximal pressure signal
- DIPRS distal pressure signal

4.2.3.6
PRESSURE SENSOR CALIBRATION

Pressure sensors are calibrated for offset and gain during mechanism calibration. A trimming potentiometer is used to adjust the initial, zero pressure offset. The proximal and distal pressure sensors have independent offset adjustments. The final system gain (cassette pressure to corrected amplifier output) is adjusted in software. During mechanism calibration, each channel's gain (amplifier output/cassette pressure) will be measured, and stored in the serial EEPROM on the driver PWA.

4.2.3.7
CASSETTE TYPE/PRESENCE SELECTION

The mechanism subsystem includes one force sensing resistor (FSR) switch, which is coupled to the cassette and is used for cassette present detection. The FSR is a polymer thick film device, which exhibits a decrease in resistance with any increase in force applied to the active surface. The FSR is arranged in a voltage divider configuration with a fixed resistor, followed by a comparator with hysteresis. The comparator circuits are located on the CPU PWA. The comparators are designed to trip as the FSR's resistance falls below 120 KΩ.

4.2.3.8
SERIAL EEPROM

The driver PWA holds the 8 K x 8 bit, serial EEPROM, which is used to store event, alarm, malfunction, and calibration data specific to the pumping mechanism. It is accessed through a serial peripheral interface (SPI) compatible interface, which is a high-speed serial interface to the CPU. The CPU PWA accesses this device through its SCP serial interface. This interface is a subset of the SPI, and consists of clock (SPCLK), data in (SPRXD), and data out (SPTXD) pins. This device is in the driver PWA to allow the calibration data to stay with the mechanism.

4.3 PRINTED WIRING ASSEMBLIES

Infusion system electronics are packaged into six printed wiring assemblies (PWA) and several remote mounted peripherals *(see Section 4.4)*. The following sections provide a brief description of the functional interfaces of each PWA.

4.3.1 POWER SUPPLY PWA

The power supply PWA *(see Figure 9-10)* contains the following functions of the power supply subsystem:

- Main switching regulator
- AC power detection
- Main regulator fault detection
- System power
- Auxiliary supplies
- Power control
- Battery management

The power supply PWA is a four layer board, with primarily surface mount technology (SMT) components. The board is fully testable from the bottom side. Insulating tape covers the back of the power supply PWA. Open system troubleshooting should be done under battery power. If connection to the AC line is required, an isolation transformer should be used since AC line potentials are present on the power supply PWA.

See *Section 4.2.2* for a functional description, and see *Table 4-5* for power supply PWA interface connections.

Table 4-5. Power Supply PWA Interface Connections

Connector	Type	Interface
P2	30 pin receptacle	Board-to-board connection to CPU PWA
J16	4 pin header	Motor power connection to driver PWA
J21	3 pin receptacle	AC power cord connection
J22	2 pin header	Battery cable connection

4.3.2 PERIPHERAL PWA

The peripheral PWA *(see Figure 9-11)* contains part of the CPU subsystem circuitry, including system program and data memories (PROM and SRAM), external communication interface circuits, and rear instrument user controls. The peripheral PWA is designed to be field replaceable, to facilitate software upgrades or additional external interfaces.

The peripheral PWA is a four layer board, including one ground plane, one power plane, and two signal layers. In its initial configuration, all of the components are mounted on the top side.

See *Section 4.2.1* for a functional description, and see *Table 4-6* for peripheral PWA interface connections.

Table 4-6. Peripheral PWA Interface Connections

Connector	Type	Interface
P1	96 pin receptacle	Board-to-board connection to CPU PWA
J26	15 pin D-sub	DataPort
J27	9 pin D-sub	Barcode reader connection
J28	3 pin phone jack	Nurse call jack

4.3.3 CPU PWA

The CPU PWA *(see Figure 9-12)* contains most of the CPU subsystem functions, with the exception of main memory and communications ports, which are located on the peripheral PWA. The CPU PWA also accommodates system interconnect.

The CPU PWA is an eight layer board, with one ground plane, one power plane, and six signal layers. The CPU PWA primarily contains SMT components. Most of the components are on the top side, while the bottom side holds wave-solder compatible SMT resistors and capacitors.

See *Section 4.2.1* for a functional description, and see *Table 4-7* for CPU PWA interface connections.

Table 4-7. CPU PWA Interface Connections		
Connector	**Type**	**Interface**
J7	96 pin header	Connection to peripheral PWA (CPU bus; rear panel I/O; communication ports)
J2	30 pin header	Connection to power supply PWA
J3	50 pin SMT	Ribbon cable connection to driver PWA (mechanism)
J4	21 pin header	Front panel connector (keypad; LEDs; ON/OFF switch)
J5	14 pin SMT	Flat flex cable to LCD panel
J6	4 pin header	Lock box connector
J20	4 pin header	CCFT backlight connector
J24	2 pin header	Main audible alarm connector

4.3.4 DRIVER PWA

The driver PWA *(see Figure 9-13)* contains the mechanism subsystem's motor drive circuitry, motor position sensors, and serial EEPROM. The driver PWA is mounted in the mechanism sub-chassis.

The driver PWA is a four layer board, with one ground plane, one power plane and two signal layers. The driver PWA primarily uses SMT components. Most of the components are located on the top side of the board, while the bottom side holds wave-solder compatible resistors and capacitors.

See *Section 4.2.3* for a functional description, and see *Table 4-8* for driver PWA interface connections.

Table 4-8. Driver PWA Interface Connections		
Connector	**Type**	**Interface**
J7	6 pin header	Plunger motor
J8	6 pin header	Input/output motor
J9	6 pin header	Line select motor
J10	20 pin SMT	Flat flex cable to APP PWA
J11	50 pin header	Ribbon cable to CPU PWA
J12	6 pin SMT	FSR flex circuit
J13	4 pin header	Motor power from power supply PWA
J14	8 pin SMT	Flat flex cable to switch PWA

4.3.5
SWITCH PWA

The switch PWA *(see Figure 9-14)* contains the plunger translation position sensor, which is one of six position sensors in the system. The switch PWA is located at the side of the mechanism sub-chassis, and connects to the driver PWA.

4.3.6
APP PWA

The APP (air, pressure, and pin) PWA *(see Figure 9-15)* is mounted in the mechanism sub-chassis. The APP PWA contains the following mechanism subsystem circuitry:

- Proximal and distal air sensors and circuitry
- Proximal and distal pressure sensor amplifiers and excitation
- V2_5 precision voltage reference
- Pin detector optical switch module

The APP PWA is a four layer board, with one ground plane, one power plane and two signal layers. The APP PWA uses SMT components, mounted on both sides of the board. The air sensors and the pin detector module are board mounted.

See *Section 4.2.3* for a functional description, and see *Table 4-9* for APP PWA interface connections.

Table 4-9. APP PWA Interface Connections

Connector	Type	Interface
J15	20 pin SMT	Flat flex cable to driver PWA
J11	10 pin SMT	Pressure sensor connector

4.4
REMOTE MOUNTED PERIPHERALS

The following sections describe the major remote mounted peripherals.

4.4.1
LCD

The infuser uses a graphic LCD module with a CCFT. The CCFT provides a backlight source for the LCD. The LCD requires a nominal -16 V_{DC} supply for contrast control, which is controlled by the CPU. The infuser's graphic display data is shifted out to the LCD by the CPU LCD controller, which interfaces directly with the CPU *(see Section 4.2.1.6)*. The display is configured as a 240 x 240 dot matrix with a viewing angle of approximately 60°.

4.4.2
SEALED LEAD ACID BATTERY

The infuser uses a nominal 6 V_{DC} rechargeable sealed lead acid battery with a 4 amp-hour capacity.

4.4.3
BARCODE READER WAND

Note: The barcode reader feature will not be present on later versions of the Plum A+®.

The barcode reader wand connects to the BCR port on the peripheral PWA *(see Figure 9-11)*. The BCR wand interfaces through the infuser's optically isolated, TTL logic level, asynchronous interface. The BCR wand is also capable of interfacing at RS-232 levels. The infuser provides an isolated +5 V_{DC} regulator to power the BCR wand. When the LED at the tip of the BCR wand is swiped across a barcode label, the reflected light is scanned and processed. After a successful scan, the data is sent over the communication interface to the CPU.

4.5
MECHANICAL OVERVIEW

The principal mechanical elements of the infuser include the cassette and the mechanism assembly. When a cassette is locked into the operating position and the [ON/OFF] switch is pressed, the infuser performs a self test to verify the integrity of the internal systems. The operation of the mechanism assembly moves a plunger, causing a pumping action. A valve motor selects the A or B valve, depending on the command. An additional valve motor alternately opens and closes an inlet valve and outlet valve to control fluid flow through the cassette pumping chamber.

The following sections detail the cassette and the mechanism assembly.

4.5.1
CASSETTE

The cassette operates on a fluid displacement principle to volumetrically deliver fluid *(see Figure 4-6* and *Figure 4-7)*. See the system operating manual for a description of the major cassette functions.

The pumping cycle begins when the outlet valve is opened and the inlet valve is closed. The plunger extends to deflect the cassette diaphragm and expel fluid. At the end of the pumping stroke, the outlet valve is closed, the inlet opens, the appropriate A or B valve opens, and the plunger retracts to allow fluid to refill the pumping chamber. After the pumping chamber is filled, the inlet and outlet valves are reversed, the A and B valves are closed, and the cycle repeats.

The cassette contains two chambers: an upper air trap chamber and a pumping chamber. The two chambers are separated by an inlet valve and operate together to detect air. The air trap chamber receives fluid from the intravenous (IV) container through either the A or B valve. The air trap chamber collects air bubbles from the IV line and container to prevent them from entering the pumping chamber and can collect a substantial amount of air.

A proximal air-in-line sensor (bubble detector) is located between the A/B valves and the upper air-trap chamber. The proximal air-in-line sensor detects air entering the upper air-trap chamber and initiates an audible alarm if the predetermined air collection threshold is exceeded. Similarly, a second air-in-line sensor located distal to the pumping chamber initiates an audible alarm if a predetermined amount of air is detected.

The pumping chamber receives fluid from the upper air-trap chamber through an inlet valve. A pressure sensor located in the upper air-trap chamber monitors pressure on the proximal side of the cassette. When the diaphragm covering the pumping chamber is deflected by the plunger, the pumping chamber expels fluid through an outlet valve. A pressure sensor located distal to the pumping chamber monitors pressure on the distal side of the cassette.

A flow regulator is incorporated into the cassette distal end. This flow regulator is used to manually control flow when the cassette is not inserted in the infuser. When the cassette is properly inserted into the infuser and the door is closed, a mechanism opens the flow regulator to allow the infuser to control fluid flow. When the door is opened, the same mechanism closes the flow regulator to disable fluid flow.

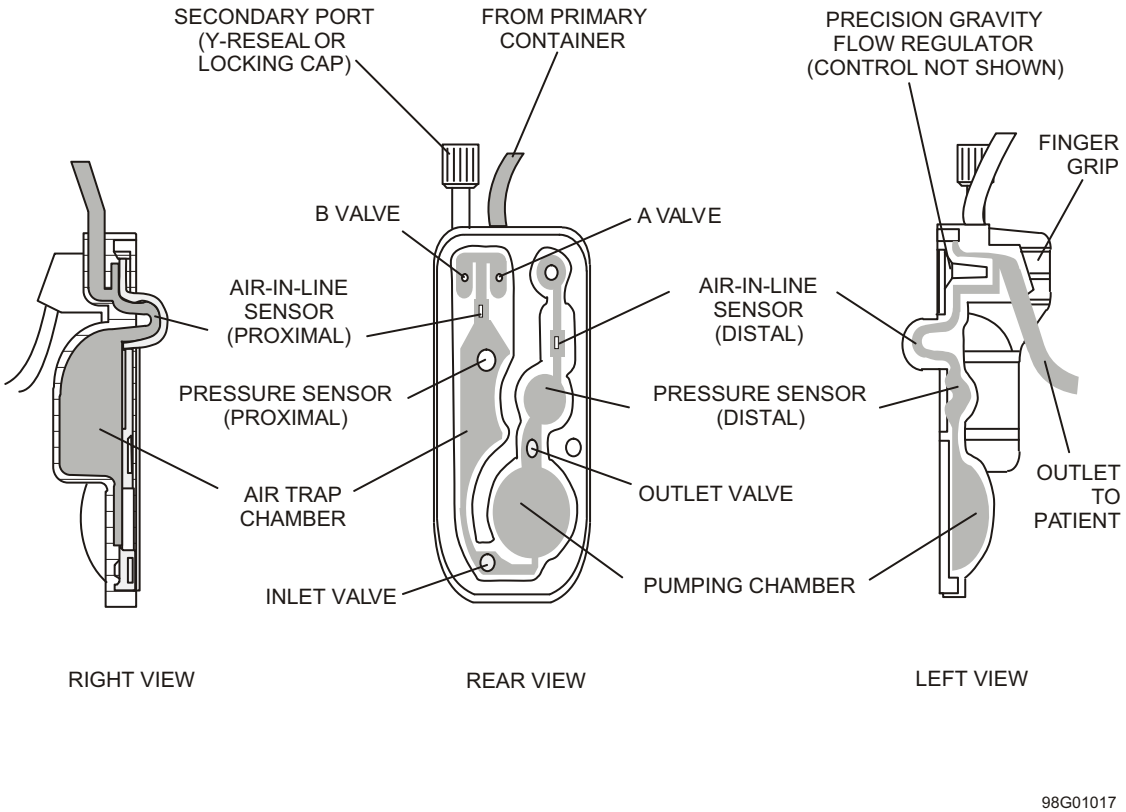

Figure 4-6. Major Elements of the Dual-Channel Cassette

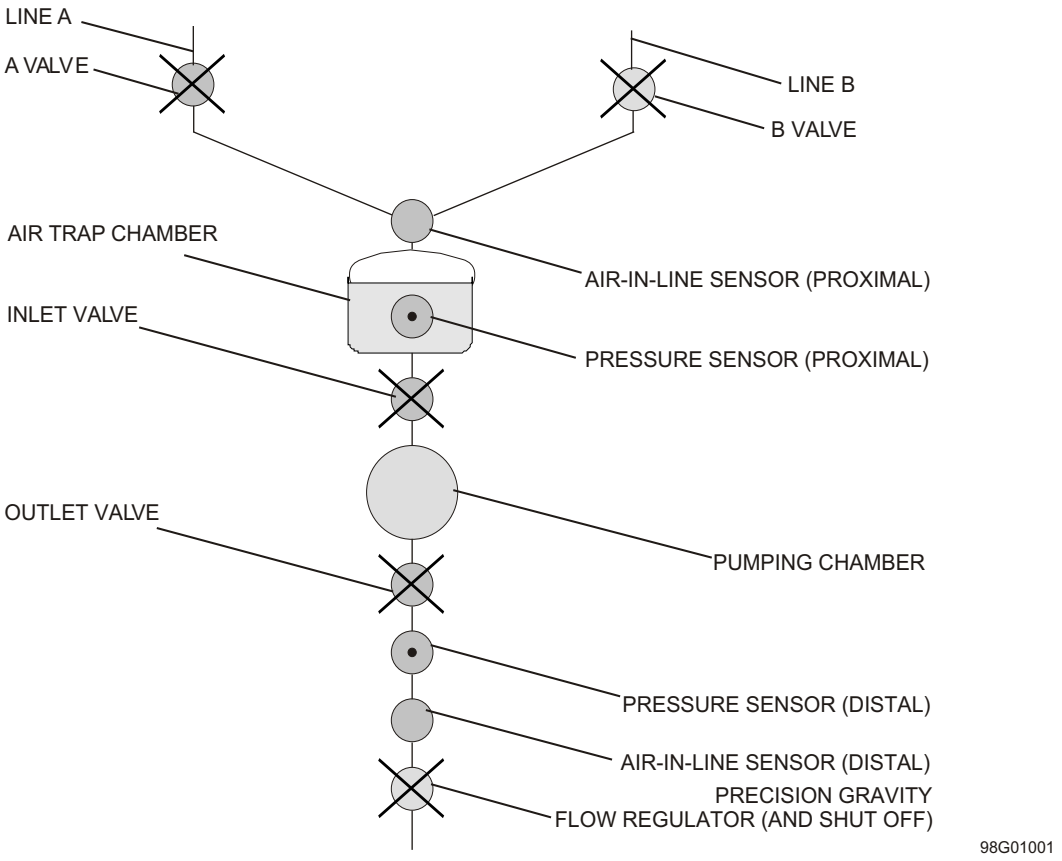

Figure 4-7. Fluid Path in the Cassette

4.5.2
MECHANISM ASSEMBLY

The mechanism assembly is a fully self-contained unit consisting of the motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, plunger drive subsystem, air bubble (ultrasonic) sensor assemblies, cassette door, and pressure sensor assemblies. The motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, and plunger drive subsystem are detailed in the following sections.

During infuser operation, the mechanism assembly plunger motor drives a lead screw that is coupled to the plunger. The motor action and lead screw move the plunger forward to cause the delivery of approximately 0.33 mL of fluid per cycle. The plunger motion is synchronized to the valve motors to provide controlled fluid delivery.

4.5.2.1
MOTOR AND VALVE ASSEMBLIES

The mechanism assembly pumping action is controlled by three stepper motors. The first stepper motor, in conjunction with an associated valve assembly, activates the A valve or B valve of the cassette, depending on the command. The second stepper motor alternately opens and closes the inlet and outlet valve to control fluid delivery through the cassette pumping chamber. A third stepper motor controls plunger movement.

4.5.2.2

A/B VALVE SUBSYSTEM

The A/B valve subsystem includes a motor designed to rotate a cam. When the cam is positioned at top-dead-center (home position), both valves are closed. Clockwise rotation (when viewed from the motor side) from the home position opens the A valve, while the B valve remains closed. Counterclockwise rotation opens the B valve, while the A valve remains closed *(see Figure 4-8)*.

The A/B valve subsystem consists of a stepper motor with attached cam and integral cam flag, A and B rockers and valve pins, and a pin detector assembly. The cam flag passes through an interrupter module as it rotates with the cam. Valve home position is determined by this cam flag/interrupter module combination through predetermined factory calibration data. During operation, if the cam flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected. The rocker is the connecting link between the cam and the valve pin.

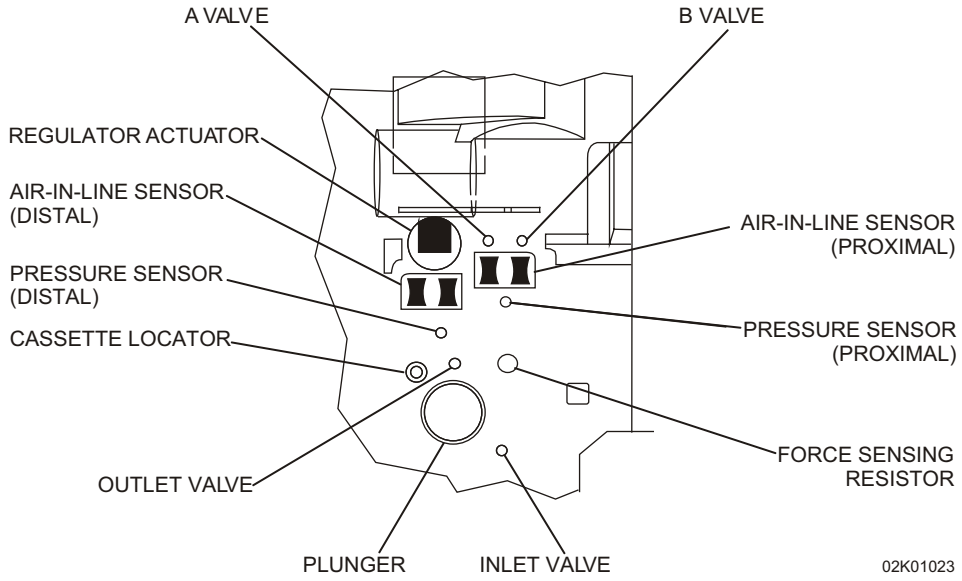

Figure 4-8. Mechanism Valve Pins and Sensor Locations

4.5.2.3
INLET/OUTLET VALVE SUBSYSTEM

The inlet/outlet valve subsystem is similar in function and build to the A/B valve subsystem *(see Section 4.5.2.2)*.

4.5.2.4
PLUNGER DRIVE SUBSYSTEM

The main components of the plunger drive subsystem are: plunger, lead screw and coupler, and stepper motor. When the infuser is turned on, the plunger moves from the retracted, PARK position to the HOME position. The cassette diaphragm is engaged. The stepper motor rotates approximately 1 2/3 revolutions per pump cycle to permit a 0.33 mL fluid displacement every pump cycle. The stepper motor then reverses and the plunger returns to HOME position. This cycle repeats for the duration of fluid administration.

The screw/coupler assembly links the motor and the plunger. This assembly includes a flag that passes through an interrupter module. This screw/coupler, flag/interrupter module combination is used in conjunction with predetermined factory calibration data to determine the plunger position. During operation, if the screw/coupler flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected.

Section 5

MAINTENANCE AND SERVICE TESTS

A complete maintenance program promotes infusion system longevity and trouble-free operation. Such a program should include routine maintenance, periodic maintenance inspection, and following any repair procedure, performance verification testing.

5.1 ROUTINE MAINTENANCE

Routine maintenance consists of basic inspection and cleaning procedures. As a minimum requirement, inspect and clean the infuser after each use. In addition, establish a regular cleaning schedule for the device.

5.1.1 CLEANING

Accumulation of dust or spilled fluids on the cassette door and housing can affect proper operation. The following cleaning procedures are designed to sustain longevity and promote trouble-free operation.

Follow hospital protocol for establishing the infuser cleaning schedule.

WARNING: DISCONNECT THE INFUSER FROM AC POWER PRIOR TO CLEANING THE DEVICE. FAILURE TO COMPLY WITH THIS WARNING COULD RESULT IN ELECTRICAL SHOCK.

CAUTION: Do not immerse the infuser in liquids. Immersion could damage the device. Do not allow liquids to enter the electronics compartment. Do not spray cleaning solutions toward any openings in the device.

CAUTION: Certain cleaning and sanitizing compounds may slowly degrade components made from some plastic materials. Using abrasive cleaners or cleaning solutions not recommended by Hospira may result in product damage and, potentially, void the product warranty. Do not use compounds containing combinations of isopropyl alcohol and dimethyl benzyl ammonium chloride. Do not use solvents that are harmful to plastic.

CAUTION: To avoid damage to the device, cleaning solutions should be used only as directed in *Table 5-1*. The disinfecting properties of cleaning solutions vary; consult the manufacturer for specific information.

Table 5-1. Cleaning Solutions		
Cleaning Solution	**Manufacturer**	**Preparation**
Coverage™ HB	Steris Corporation	Per manufacturer's recommendation
Dispatch™	Caltech Industries	Per manufacturer's recommendation
Manu-Klenz®	Steris Corporation	Per manufacturer's recommendation
Precise™	Caltech Industries	Per manufacturer's recommendation
Sporicidin®	Sporicidin International	Per manufacturer's recommendation
Household bleach	Various	Per hospital procedures; do not exceed one part bleach in ten parts water

1. Clean the exposed surfaces of the infusion system with a soft, lint-free cloth dampened with one of the cleaning solutions listed in *Table 5-1*, or a mild solution of soapy water.
2. Remove soap residue with clear water.

5.1.2
SANITIZING

Sanitize the external surfaces of the infuser using a cleaning solution listed in *Table 5-1*.

Note: Not all cleaning solutions are sanitizers. Check product labeling.

CAUTION: Do not sterilize the infuser using heat, steam, ethylene oxide (ETO), or radiation. These methods may cause the device to malfunction.

5.2
PERFORMANCE VERIFICATION TEST

The performance verification test (PVT) consists of the tests described in the following sections. The PVT can be used for diagnostic purposes during the troubleshooting of a malfunctioning infuser. The PVT should be used for performance verification before an infuser is placed back in service after repair. If any malfunction is detected as a result of the PVT, see *Table 6-3*.

Note: Perform the PVT exactly as described in this manual to assure effective and reliable product evaluation information.

5.2.1
EQUIPMENT REQUIRED

The PVT requires the following equipment and materials, or equivalents:

- Graduated cylinder, 25 mL, with 0.2 mL graduations (Type A)
- Sterile water or tap water in an IV bag/container
- Digital pressure meter (DPM), 0 to 50 psi (Fluke® Biomedical DPM3)
- Three-way stopcock, latex-free (List No. 3233-01)
- IV Set (List No. 11419)
- 21-gauge butterfly needle, latex-free (List No. 4492-01), or 18-gauge blunt cannula
- Safety analyzer (Fluke® Biomedical 232D)
- Digital multimeter (DMM) (Fluke® 187) (optional)
- Nurse call test cable (P/N 561-88416-001) (optional)

5.2.2
INSPECTION

Inspect the infusion system periodically for signs of defects such as worn accessories, broken connections, or damaged cables. In addition, inspect the infuser after repair or during cleaning. Replace any damaged or defective external parts.

Inspect the following areas for missing or damaged parts:

- Labels
- AC power cord, retainer, and strap
- Rubber foot pads
- Door assembly and handle
- Keypad and display
- LEDs
- External screws
- Pole clamp assembly
- Front and rear enclosures
- Battery door
- Peripheral assembly and components

5.2.3
TEST SETUP

WARNING: A PATIENT SHOULD NEVER BE CONNECTED TO THE INFUSER DURING TESTING.

To set up the infuser for the PVT, proceed as follows:

1. Confirm the infuser and appropriate accessories are assembled.
2. Hang two sterile water containers at a height of 18 inches ± 6 inches above the pumping chamber of the infuser.
3. Connect the infuser to AC power, and press [ON/OFF] to turn on the device.
4. Verify the infuser is in the **unlocked** mode. Toggling the [LOCKOUT] switch alternates between **unlocked** [DOWN] and **locked** [UP] modes.
5. Turn off the infuser.

5.2.4
SELF TEST

CAUTION: Do not place the infuser in service if the self test fails.

Note: Conduct all tests with the infuser connected to AC power unless otherwise specified.

Note: If an alarm condition occurs during the self test, cycle the power and repeat the self test. If the alarm condition recurs, note the message and take corrective action *(see Section 6)*. Repeat the self test. If the alarm condition continues to recur, remove the infuser from service and contact Hospira.

To perform the self test, see *Figure 5-1*, then proceed as follows:

1. Connect the AC power cord to a grounded AC outlet. Verify the charge/line indicator **CHARGE** illuminates and an alarm beep sounds.
2. Without a cassette installed, turn on the infuser.
3. The LCD screen briefly displays the **SELF TEST** screen *(see Figure 5-1)*.

   Note: If the **SELF TEST** screen does not appear, contact Hospira.

4. After the self test is complete, the message “INSERT PLUM SET CLOSE LEVER” appears.
5. Verify the time and date. To set the time and date, see *Section 1.8.3*.
6. Open the cassette door and insert a primed cassette. Close the cassette door. The cassette test is complete when the “CASSETTE TEST IN PROGRESS” message disappears.

   Note: The message “MECHANISM INITIALIZATION IN PROGRESS” may briefly appear prior to the “CASSETTE TEST IN PROGRESS” message.

7. A “NEW PATIENT?” message may appear. Press [YES], then turn off the infuser.

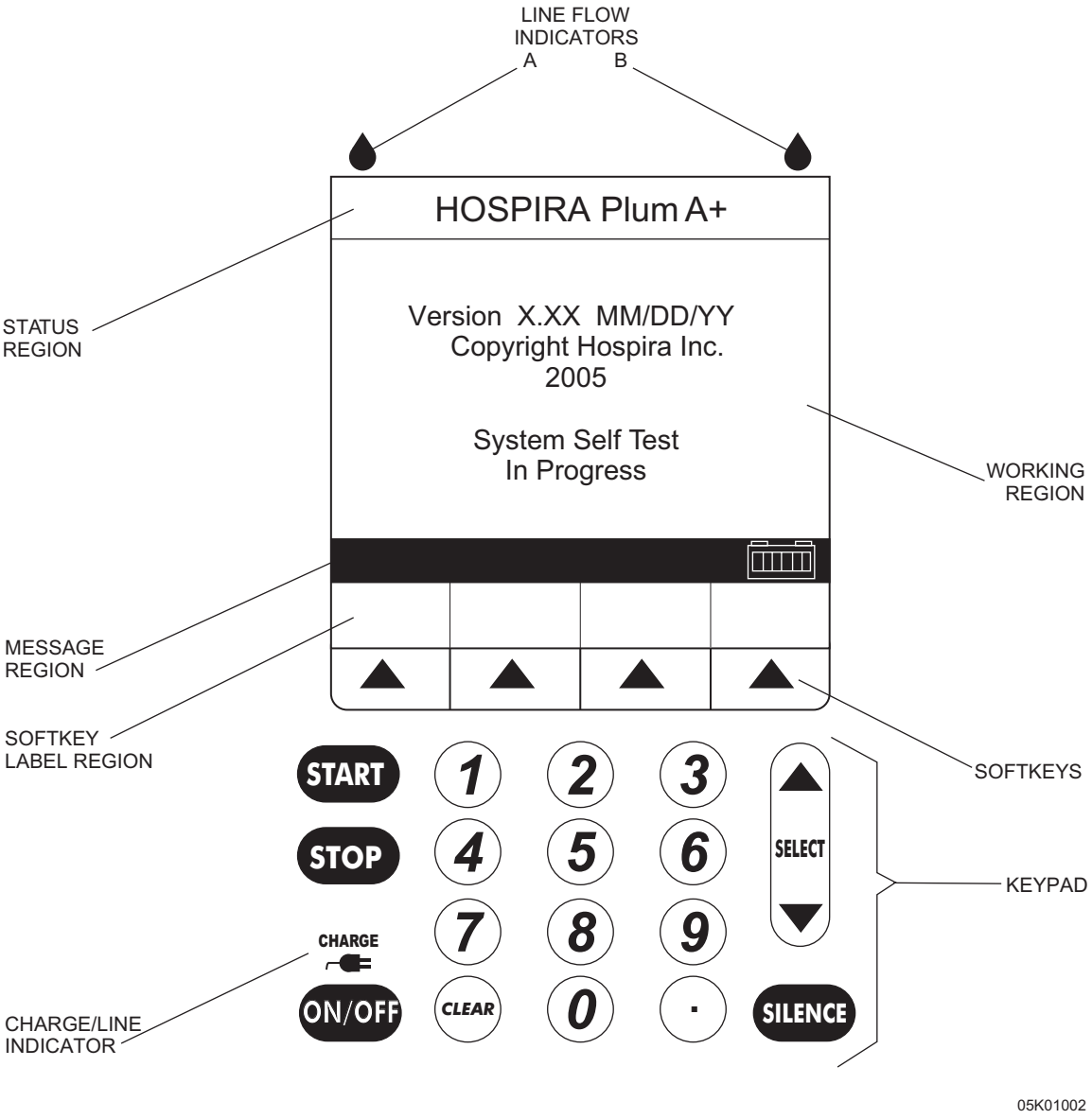

Figure 5-1. Display and Keypad

5.2.5
CASSETTE ALARM TEST

To perform the cassette alarm test, proceed as follows:

1. Verify the infuser is on. Insert an empty cassette and close the door.

   Note: The infuser may display a CCA screen. Choose an area and press [ENTER].

2. Verify the "CASSETTE TEST FAIL" message is flashing on the display and the alarm sounds after the cassette test is complete.
3. Open the door and remove the cassette.
4. Turn off the infuser.

5.2.6
FREE FLOW TEST

To perform the free flow test, proceed as follows:

1. With a primed cassette installed, press [ON/OFF] to turn on the infuser.

   Note: The infuser may display a CCA screen. Choose an area and press [ENTER].

2. A "NEW PATIENT?" message may appear. Press [YES].
3. Place the distal end of tubing into a collection container a minimum of 36 inches below the cassette.
4. With the cassette door closed, check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).
5. Open the cassette door and check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).

   Note: A small amount of fluid may be expelled from the cassette when opening or closing the door.

6. Close the cassette door.

5.2.7
DISPLAY TEST

To perform the display test, see *Figure 5-1*, then proceed as follows:

1. Verify the LCD backlight is illuminated and the display is clearly legible at eye level from approximately 18 inches.
2. With the infuser in the **DELIVERY** screen, press the [OPTIONS/VOL INF] softkey to select the **OPTIONS** screen.
3. Select **Lighting/Contrast**, and press [CHOOSE].
4. Press the [DECREASE SETTING] and [INCREASE SETTING] softkeys to change backlight intensity. Verify backlight intensity decreases and increases.
5. Select **Display Contrast**.

6. Press [DECREASE SETTING] and [INCREASE SETTING] to change display contrast. Verify the display contrast decreases and increases.
7. Press the [CANCEL] softkey to return to the **OPTIONS** screen.
8. Press the [BACK] softkey to return to the **DELIVERY** screen.

5.2.8 KEYPAD VERIFICATION/FUNCTIONAL TEST

To perform the keypad verification/functional test, see *Figure 5-1*, then proceed as follows:

1. With the infuser in the **DELIVERY** screen, press the [A] softkey to select line A.
2. Verify the **PROGRAM** screen is displayed.
3. Enter a rate of 123 mL/hr and VTBI of 4567.
4. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES].
5. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
6. Press [STOP], then press and hold the [BACKPRIME] softkey.
7. Verify the “BACKPRIMING” and “RELEASE BACKPRIME TO STOP” messages are displayed, and verify the infuser is actually backpriming.
8. Release the [BACKPRIME] softkey, press [START], and verify normal pumping operation.
9. Press the [B] softkey.
10. Verify **PIGGYBACK** is the displayed delivery mode. If necessary, change the delivery mode by pressing the [CHANGE MODE] softkey.
11. Enter a rate of 890 mL/hr and VTBI of 2 mL.
12. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES].
13. Verify fluid is pumping. Verify the message “PUMPING” is displayed in the line B status bar, and the line B LED flashes.
14. After 20 seconds, verify pumping has switched to line A.
15. Press [STOP].
16. Press [OPTIONS/VOL INF]. Select **Volume Infused** and press [CHOOSE].
17. Select line A.
18. Press [CLEAR]. Verify the line A volume is 0 mL and press [ENTER].

5.2.9
ALARM LOUDNESS TEST

To perform the alarm loudness test, proceed as follows:

1. Press the [A] softkey to select line A.
2. Enter a rate of 400 mL/hr and VTBI of 1 mL.
3. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES].
4. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
5. Verify the alarm sounds when the dose has been delivered.
6. Turn the volume control knob between HIGH and LOW *(see Figure 5-2)*. Verify the alarm loudness changes.
7. Press the [SILENCE] key, and verify the alarm is silenced.
8. Press [STOP].

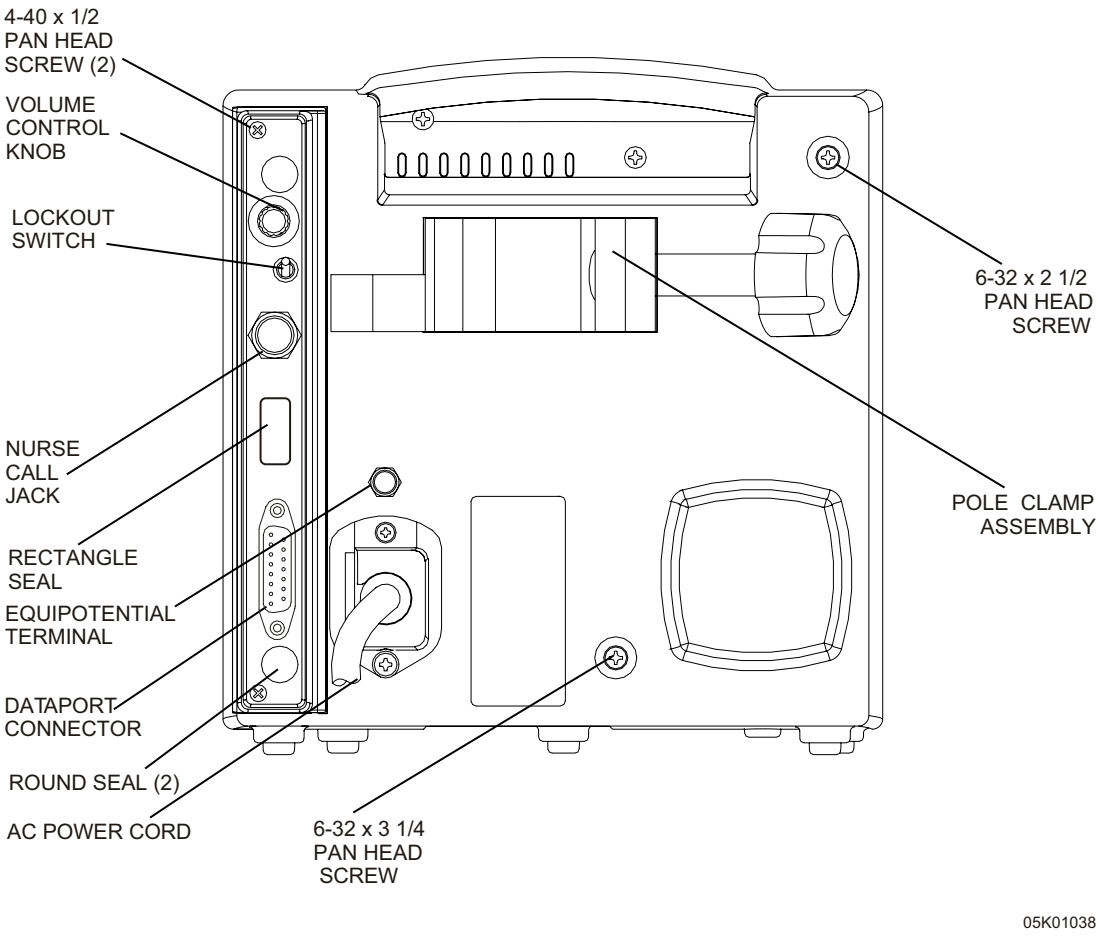

Figure 5-2. Rear View

5.2.10
LOCKOUT SWITCH TEST

To perform the lockout switch test, proceed as follows:

1. Press the [A] softkey to select line A.
2. Enter a rate of 400 mL/hr and VTBI of 50 mL.
3. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES].
4. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
5. Toggle the lockout alarm switch up (ON) to engage the alarm *(see Figure 5-2)*.
6. Press any key except [STOP], and verify an alarm sounds and the "HARD LOCKOUT ENABLED" message is displayed. Verify the infuser continues to operate until [STOP] is pressed.
7. Press [STOP] and verify the "HARD LOCKOUT VIOLATION" message appears.
8. Toggle the lockout alarm switch down (OFF). Verify the "HARD LOCKOUT VIOLATION" message disappears and the alarm stops.
9. Press [START].
10. Open the door and verify the "DOOR OPEN WHILE PUMPING" message is displayed and the audio alarm activates.
11. Close the cassette door.
12. Press [NO] at the "NEW PATIENT?" prompt.

5.2.11
PROXIMAL OCCLUSION TEST

To perform the proximal occlusion test, proceed as follows:

1. Press the [A] softkey to select line A.
2. Enter a rate of 400 mL/hr and VTBI of 50 mL.
3. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES].
4. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
5. After several pumping cycles, clamp line A tubing proximal to the cassette. Verify the "PROX OCCL A/AIR" message flashes and the alarm sounds before three pumping cycles are completed.
6. Press [SILENCE] and verify the alarm stops while the message on the display continues to flash.
7. Unclamp the proximal line and press [START]. Verify pumping resumes.
8. Press [STOP].

5.2.12
PROXIMAL AIR-IN-LINE TEST

To perform the proximal air-in-line test, see *Figure 5-3*, then proceed as follows:

1. Install the special cassette marked **proximal**, and close the cassette door.

   Note: Confirm the special cassette proximal bubble sensor tips are removed.

2. A "NEW PATIENT?" message may appear. Press [YES].
3. Press the [A] softkey to select line A.
4. Enter a rate of 400 mL/hr and VTBI of 50 mL.
5. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES].
6. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
7. Before 1 mL of fluid is delivered, verify the alarm sounds and the "PROX AIR A. BACKPRIME" message is flashing on the display.
8. Open the door and remove the special cassette.

5.2.13
DISTAL AIR-IN-LINE TEST

To perform the distal air-in-line test, see *Figure 5-3*, then proceed as follows:

1. Install the special cassette marked **distal**, and close the cassette door.

   Note: Confirm the special cassette distal bubble sensor tips are removed.

2. A "NEW PATIENT?" message may appear. Press [YES].
3. Press the [A] softkey to select line A.
4. Enter a rate of 400 mL/hr and VTBI of 50 mL.
5. Press [START] and verify the "CONFIRM PROGRAM?" message is displayed. If rate and VTBI are correct, press [YES].
6. Verify fluid is pumping, the message "PUMPING" is displayed in the line A status bar, and the line A LED flashes.
7. Before 1 mL of fluid is delivered, verify the alarm sounds and the "DISTAL AIR A. BACKPRIME" message is flashing on the display.
8. Open the door and remove the special cassette.

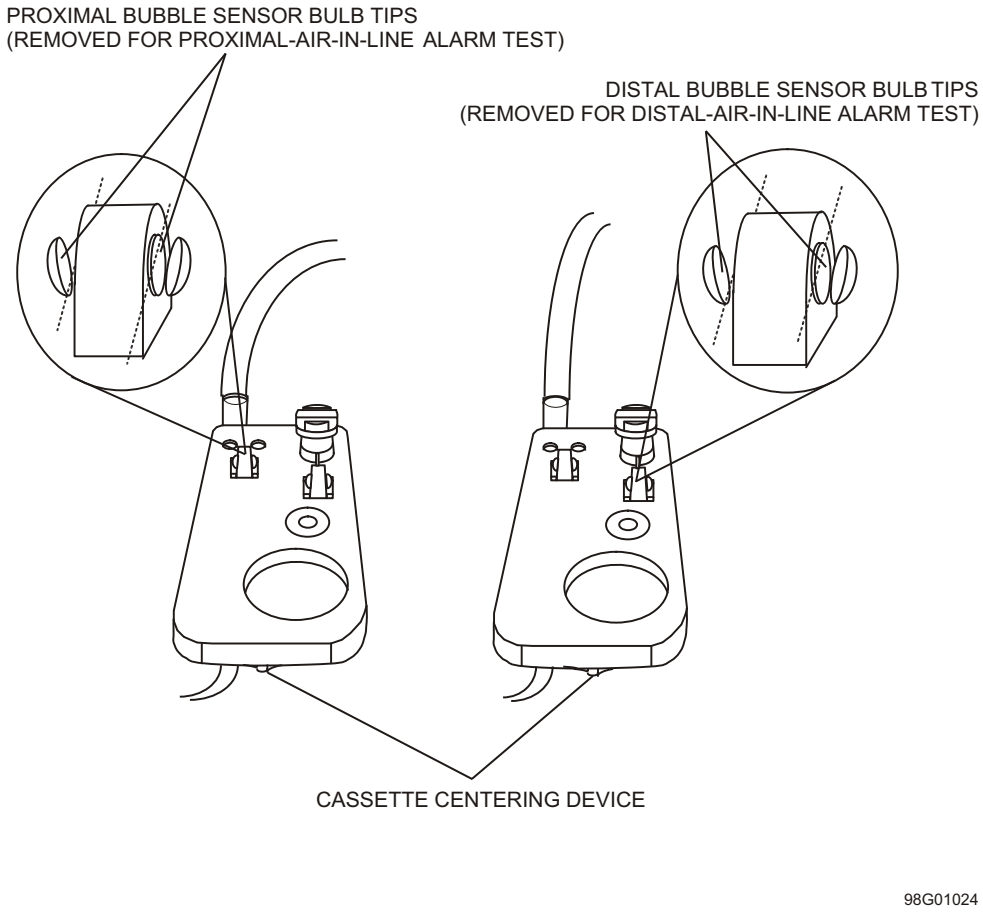
PROXIMAL BUBBLE SENSOR BULB TIPS
(REMOVED FOR PROXIMAL-AIR-IN-LINE ALARM TEST)
DISTAL BUBBLE SENSOR BULB TIPS
(REMOVED FOR DISTAL-AIR-IN-LINE ALARM TEST)
CASSETTE CENTERING DEVICE
98G01024

Figure 5-3. Special Cassettes with Bubble Sensor Tips Removed

5.2.14
DISTAL OCCLUSION TEST

To perform the distal occlusion test, see *Figure 5-4*, then proceed as follows:

1. Install the cassette and connect the distal tubing to the DPM through a three-way stopcock as illustrated in *Figure 5-4*. Close the cassette door.

   Note: A reflux valve may be attached between the stopcock and the DPM to keep moisture out of the DPM.

   Note: The height of the DPM must be 0 ± 12 inches from the midline of the pumping chamber.

2. Turn on the infuser.
3. A “NEW PATIENT?” message may appear. Press [YES].
4. Press [OPTIONS/VOL INF] to select the **OPTIONS** screen.
5. Select **Pressure/Post Infusion Rate**, and press [CHOOSE].
6. Verify the distal pressure limit is set at 6 psi. If the pressure limit is not 6 psi, enter 6, and press [ENTER].
7. Press the [A] softkey to select line A.
8. Enter a rate of 40 mL/hr and VTBI of 50 mL.
9. Open the three-way stopcock to air.
10. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES].
11. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
12. Set the three-way stopcock to measure pressure.
13. Verify the distal occlusion audible alarm occurs at 6 psi ±3 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
14. Open the three-way stopcock to air.
15. Open and close the door. Press [NO] at the “NEW PATIENT?” prompt.
16. Press [OPTIONS/VOL INF] to select the **OPTIONS** screen.
17. Select **Pressure/Post Infusion Rate** and press [CHOOSE].
18. Select **Distal Pressure Limit**. Enter 10 psi, and press [ENTER].
19. Set the three-way stopcock to measure pressure, then press [START].
20. Verify the distal occlusion audible alarm occurs at 10 psi ±3 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
21. Open the door and remove the cassette.

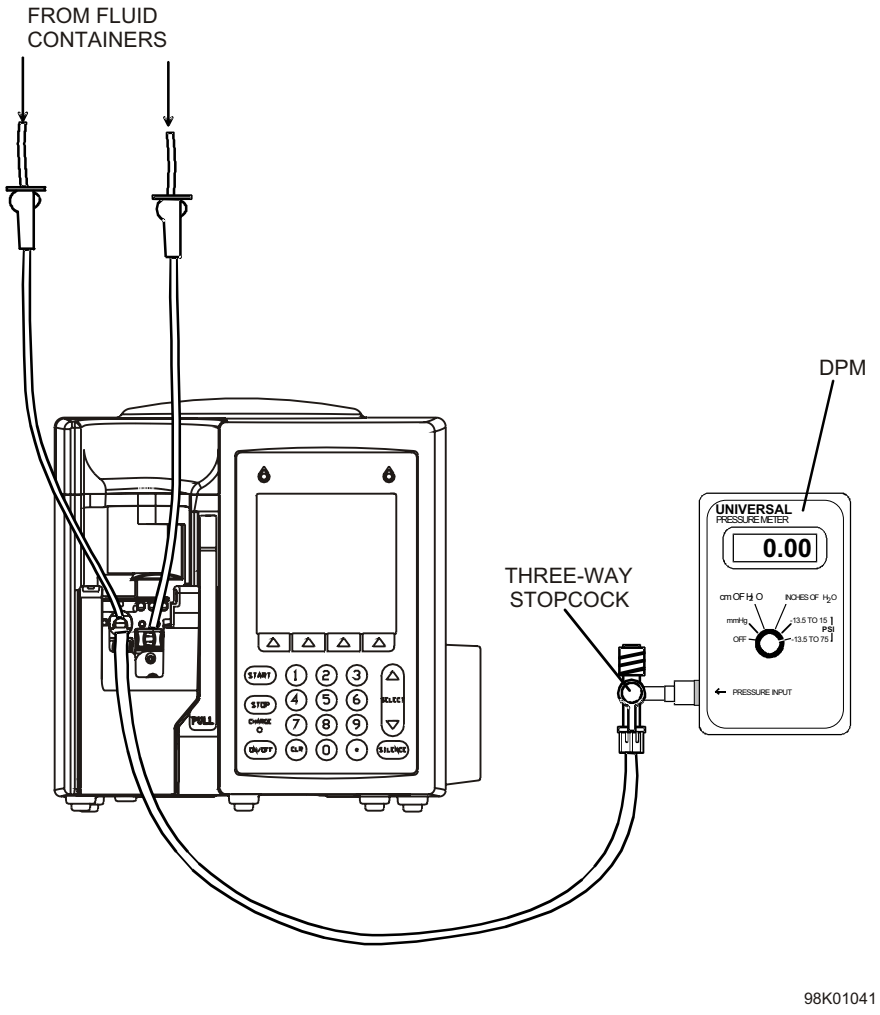

Figure 5-4. Distal Occlusion Test Setup

5.2.15
DELIVERY ACCURACY TEST

Note: Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern as to infuser accuracy, contact Hospira.

CAUTION: Do not remove the protective cover from the 21-gauge needle.

To perform the delivery accuracy test, proceed as follows:

1. Open the cassette door and insert a primed cassette. Close the cassette door.
2. A “NEW PATIENT?” message may appear. Press [YES].
3. Install an 18-gauge blunt cannula or a 21-gauge needle to the distal end of the tubing. Verify the fluid container is 18 to 24 inches above the pumping chamber. Verify all lines are unclamped.
4. Place the distal output end of tubing into the graduated cylinder.
5. Press the [A] softkey to select line A.
6. Enter a rate of 200 mL/hr and VTBI of 10 mL.
7. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES].
8. Verify fluid is pumping, the message “PUMPING” is displayed in the line A status bar, and the line A LED flashes.
9. Press the [B] softkey to select line B.
10. Verify the infuser is in the **PIGGYBACK** delivery mode. If necessary, press [CHANGE MODE] to change the delivery mode.
11. Enter a rate of 200 mL/hr and VTBI of 10 mL.
12. Press [START] and verify the “CONFIRM PROGRAM?” message is displayed. If rate and VTBI are correct, press [YES].
13. Verify fluid is pumping, the message “PUMPING” is displayed in the line B status bar, and the line B LED flashes.
14. Verify the “KVO” message flashes on the display and an audible alarm sounds when total delivery is complete on line A.
15. Press [STOP] and verify the volume delivered is 20 mL ± 1 mL.

5.2.16
NURSE CALL TEST

Note: The nurse call test may be bypassed if the nurse call function is not used.

To perform the nurse call test, attach the nurse call test cable and proceed as follows:

1. Set the primary delivery rate to 400 mL/hr, and the primary dose limit to 1 mL.
2. Connect a DMM to the nurse call test cable.
3. Press [START] and verify pumping action.
4. After “DOSE END” and “KVO” appear on the display, observe a short circuit on the DMM (approximately 1 Ω on a scale of 0 to 100 Ω).

5.2.17
ELECTRICAL SAFETY TEST

To perform the electrical safety test, proceed as follows:

1. Connect the AC power cord to a safety analyzer.
2. Connect the safety analyzer ground lead to the ground test-point located on the rear of the infuser.
3. Check the leakage current with the safety analyzer. Leakage current (both open and closed ground) must not exceed 100 microamperes AC_{rms}.
4. Measure the resistance of the AC connector ground lug with the safety analyzer. Resistance should not exceed 0.1 Ω.

5.2.18
END OF THE PVT

If all performance verification tests have been successful, proceed as follows:

1. Press [OPTIONS/VOL INF]. Select **Volume Infused** and press [CHOOSE].
2. Press [CLEAR] to clear the volume infused.
3. Press [ENTER].
4. Press the [A] softkey.
5. Press the [CLEAR PROGRAM] softkey.
6. Press [YES] at the “CLEAR LINE A SETTINGS?” prompt.
7. Press the [CANCEL/BACK] softkey to return to the delivery screen.
8. Press the [B] softkey.
9. Press the [CLEAR PROGRAM] softkey.
10. Press [YES] at the “CLEAR LINE B SETTINGS?” prompt.
11. Reset the infuser to the original configuration.
12. Turn off the infuser and return the device to service.

Note: If any tests fail, see *Section 6*, or contact Hospira.

5.3
PERIODIC MAINTENANCE INSPECTION

Periodic maintenance inspections should be performed per hospital procedures for compliance to accreditation requirements. It is recommended that JCAHO and/or hospital protocol be followed for establishing a periodic maintenance inspection schedule. Product specifications for this inspection are listed in *Section 8*.

To perform the periodic maintenance inspection, complete the PVT in *Section 5.2*.

5.4
BATTERY OPERATION OVERVIEW

The infusion system is intended to operate on battery power on an exception basis only, such as emergency backup or temporary portable operation. Examples of emergency backup include AC power failure or inadvertent disconnection of the AC power cord. An instance of temporary portable operation includes patient transfer from one location to another.

The device should be connected to AC power whenever possible to allow the battery to remain fully charged. The line power indicator turns off when the infuser is operating on battery power. After five minutes of operation on battery power, the infuser switches its display backlight intensity to a low intensity mode.

Factors that most commonly affect battery life are the depth and frequency of discharge and the length of the recharge period. As a general rule, the more often the battery is discharged and recharged, the sooner it will need replacement. The primary cause of damage is leaving the battery in a less than fully charged state for any period of time. Battery damage can occur in a matter of hours and cause a permanent loss of battery capacity. The amount of lost capacity depends on the degree of discharge, the storage temperature, and the length of time the battery was stored in a discharged state.

Note: A permanently damaged battery cannot be recharged to full capacity.

When the battery discharges below the acceptable level while the infuser is operating, the audio indicator is activated and the “WARNING: LOW BATTERY” message displays. Although it is not recommended to continue operating the infuser on battery power at this point, the battery continues providing power until it is depleted. When the battery is depleted, delivery stops, a continuous alarm tone sounds, and, after three minutes, the infuser automatically turns off.

CAUTION: As soon as the low battery alarm occurs, connect the infuser to AC power.

When the infuser detects that the battery has reduced capacity, it will register a Replace Battery condition. For the first two occurrences of a Replace Battery condition, the “WARNING: LOW BATTERY” message will appear and the audio indicator will activate. The message and audio indicator can be cleared only when the device is plugged in or turned off. For the third and subsequent occurrences, the “WARNING: REPLACE BATTERY” message will appear, and the audio indicator will activate and persist over power cycles. The message and audio indicator are cleared by replacing the battery, accessing the biomed settings screen, and pressing the [CHANGE BATTERY] softkey.

Recharging can occur any time the infuser is connected to AC power. It is recommended that the infuser be connected to AC power whenever practical to maximize available battery charge during transport or ambulation. The infuser does not have to be on for the battery to recharge.

Note: The infuser should be operated on battery power for three continuous hours at least once every six months for optimum battery performance and life.

Section 6

TROUBLESHOOTING

This section contains information on technical assistance, warning messages, alarm messages and error codes, and troubleshooting procedures for the Plum A+® infusion system.

6.1 TECHNICAL ASSISTANCE

For technical assistance, product return authorization, and to order parts, accessories, or manuals within the United States, contact Hospira Technical Support Operations.

1-800-241-4002

For additional technical assistance, technical training, and product information, visit the website at **www.hospira.com.**

Send all authorized, prepaid returns within the United States to the following address:

Hospira, Inc.
Technical Support Operations
755 Jarvis Drive
Morgan Hill, California 95037

For technical assistance, product return authorization, and to order parts, accessories, or manuals from outside the United States, contact the nearest Hospira sales office.

6.2 WARNING MESSAGES

Table 6-1 lists warning messages, possible causes, and corrective actions. These warning messages are captured in the Error Log.

Note: When the infuser detects that the battery has reduced capacity, it will register a Replace Battery condition. For the first two occurrences of a Replace Battery condition, the "WARNING: LOW BATTERY" message will appear and the audio indicator will activate. The message and audio indicator can be cleared only when the device is plugged in or turned off. For the third and subsequent occurrences, the "WARNING: REPLACE BATTERY" message will appear, and the audio indicator will activate and persist over power cycles. The message and audio indicator are cleared by replacing the battery, accessing the biomed settings screen, and pressing the [CHANGE BATTERY] softkey.

Note: If the device is not plugged in, and turned on with a previously depleted battery, the infuser will display a "DEPLETED BATTERY" message for 16 seconds, then power off.

Table 6-1. Warning Messages		
Message	**Possible Cause**	**Corrective Action**
Stop delivery, then turn off	Attempting to turn off the infuser while a delivery is in progress	Stop all lines, then turn off the infuser
Warning: Low Battery	Battery is discharged so that only approximately 30 minutes of battery life remains	Plug into AC power
Warning: Replace Battery	Battery service needed Battery voltage is less than the depleted threshold and the charge level is higher than the low charge threshold	Replace the battery
Warning: Charger Service	A hardware problem with the battery charging circuit is detected Charging circuitry is not behaving as expected	Press [SILENCE]

6.3
ALARM MESSAGES AND ERROR CODES

Under most alarm conditions the infuser ceases normal operation, generates an audible alarm, and displays an alarm message or error code on the LCD screen.

There are two types of alarm conditions:

- alarm codes that can be cleared by the operator
- error codes that require qualified service personnel

6.3.1
OPERATIONAL ALARM MESSAGES

Table 6-2 lists infuser alarm codes that can be cleared by the operator. Also listed in *Table 6-2* are the alarm messages, descriptions, possible causes, and corrective actions.

Note: Operational alarm messages are displayed on the LCD screen. Associated error codes are displayed in the alarms log *(see Section 1.8.2)*.

Table 6-2. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N100 (URC)	Unrecognizable cassette	Incorrect cassette type	An incorrect cassette is inserted	Insert proper cassette
N101 (NAA)	No action	No operator action and no delivery for two minutes during delivery parameters entry	Interruption or a partial change to a program	Complete programming of the infuser
N102 (RL)	Infuser idle 2 minutes	Infuser in reset or idle for over two minutes	Programming set without start for two minutes	Press [START]
N103 (SEEP CRC)	NV RAM lost therapy data	Therapy data is lost	Infuser did not complete the previous non-volatile memory write successfully	Re-enter all programmed data
N104 (NC2)	Nurse callback B	Delivery line B has changed (if alarm is enabled)	End of delivery step on line B other than VTBI complete while callback is enabled	Press [SILENCE]
N105 (NC1)	Nurse callback A	Delivery line A has changed (if alarm is enabled)	End of delivery step on line A other than VTBI complete while callback is enabled	Press [SILENCE]
N160 or **E160** (VTB2)	Line B VTBI complete	Programmed volume to be infused completed on line B	VTBI is complete on line B	Press [SILENCE] and replace IV bag, and restart line B
N161 or **E161** (VTB1)	Line A VTBI complete	Programmed volume to be infused completed on line A	VTBI is complete on line A	Press [SILENCE] and replace IV bag, and restart line A
N180 or **E180** (OD1)	Distal Occl	Peak distal occlusion, non-delivery	Distal occlusion detected during non-delivery	Backprime the cassette and restart the infuser
N181 or **E181** (OD1)	Distal Occl	Negative distal occlusion, non-delivery	Distal occlusion detected during non-delivery	Backprime the cassette and restart the infuser

Table 6-2. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N182 or **E182** (OP2)	Prox. Occl B, Air or Prox. Occl B	Negative proximal occlusion B, non-delivery	Proximal occlusion detected on line B during non-delivery	Backprime the cassette and restart line B or Stop all lines, backprime the cassette, and restart all lines
N183 or **E183** (OP2)	Prox. Occl B, Air or Prox. Occl B	Peak proximal occlusion B, non-delivery	Proximal occlusion detected on line B during non-delivery	Backprime the cassette and restart line B or Stop all lines, backprime the cassette, and restart all lines
N184 or **E184** (OP1)	Prox. Occl A, Air or Prox. Occl A	Negative proximal occlusion A, non-delivery	Proximal occlusion detected on line A during non-delivery	Backprime the cassette and restart line A or Stop all lines, backprime the cassette, and restart all lines
N185 or **E185** (OP1)	Prox. Occl A, Air or Prox. Occl A	Peak proximal occlusion A, non-delivery	Proximal occlusion detected on line A during non-delivery	Backprime the cassette and restart line A or Stop all lines, backprime the cassette, and restart all lines
N186 or **E186** (OD1)	Distal Occl	Peak distal occlusion, delivery	Distal occlusion detected during delivery	Fix occlusion, and restart the infuser
N187 or **E187** (OD1)	Distal Occl	Negative distal occlusion, delivery	Distal occlusion detected during delivery	Fix occlusion, and restart the infuser
N188 or **E188** (OP2)	Prox. Occl B, Air	Negative proximal occlusion B, delivery	Proximal occlusion detected during delivery on line B	Fix occlusion, and restart line B or Stop all lines, fix occlusion, and restart the infuser

Table 6-2. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N189 or **E189** (OP2)	Prox. Occl B, Air	Peak proximal occlusion B, delivery	Proximal occlusion detected during delivery on line B	Fix occlusion, and restart line B or Stop all lines, fix occlusion, and restart the infuser
N190 or **E190** (OP1)	Prox. Occl A, Air	Negative proximal occlusion A, delivery	Proximal occlusion detected during delivery on line A	Fix occlusion and restart line A or Stop all lines, fix occlusion, and restart the infuser
N191 or **E191** (OP1)	Prox. Occl A, Air	Peak proximal occlusion A, delivery	Proximal occlusion detected during delivery on line A	Fix occlusion and restart line A or Stop all lines, fix occlusion, and restart the infuser
N230 or **E230** (APT)	Prox. Air Total	Proximal air-in-line total	500 µL of air has entered the cassette	Backprime the cassette and restart the infuser or Remove and manually reprime the cassette and restart the infuser
N231 or E231 (APB)	Prox. Air on B, Backprime	Proximal air-in-line on line B	500 µL of air has entered the cassette on line B	Backprime the cassette and restart line B or Remove and manually reprime the cassette and restart the infuser
N232 or **E232** (APA)	Prox. Air on A, Backprime	Proximal air-in-line on line A	500 µL of air has entered the cassette on line A	Backprime the cassette and restart line A or Remove and manually reprime the cassette and restart the infuser

Table 6-2. Operational Alarm Messages and Corrective Actions

Alarm Code	Alarm	Description	Possible Cause	Corrective Action
N233 or **E233** (ADC)	Distal air cumulative	Distal air cumulative	500 µL of air detected in the last 5.3 mL of fluid delivered	Remove and manually reprime the cassette and restart the infuser
N234 or **E234** (ADB)	Distal air bolus	Distal air bolus	100 µL bolus of air detected at distal sensor	Remove and manually reprime the cassette and restart the infuser
N250 or **E250** (DCO1)	Door opened while pumping	Door opened while pumping	Door opened while pumping	Turn off the infuser or Insert the cassette and close the door
N251 or **E251** (CS1)	Valve/cass test fail	Valve/cassette test failure	Valve/cassette fails the leak test	Replace cassette and retest or Backprime and retest
N252 or **E252** (BDP)	Depleted battery	Low battery	The battery terminal voltage is less than 5.45 V	Connect the infuser to AC power or Recharge or replace the battery
N253 or **E253** (LOV)	Lockout violation	Hard lockout violation	The use of the [STOP] key or an attempt to open the door while the lockout switch is locked	Unlock the lockout switch
N254 or **E254** (FPL)	Lockout enabled	Keypad locked	Any action not resulting in stopping of delivery while the lockout switch is locked	Unlock the lockout switch

Table 6-2. Operational Alarm Messages and Corrective Actions				
Alarm Code	**Alarm**	**Description**	**Possible Cause**	**Corrective Action**
N255 (SLV)	Lockout violation	Soft lockout violation	The use of the [STOP] key or an attempt to open the door while the lockout switch is locked	Unlock the software lockout switch
N256 (SLV)	Lockout enabled	Soft lockout enabled	Any action not resulting in stopping of delivery while the lockout switch is locked	Unlock the software lockout switch

6.3.2
ERROR CODES REQUIRING TECHNICAL SERVICE

Table 6-3 lists infuser error codes that require technical service. Also listed in *Table 6-3* are malfunction descriptions, possible causes, and corrective actions.

Table 6-3. Error Codes Requiring Technical Service			
Error Code	**Malfunction**	**Possible Cause**	**Corrective Action**
E300	ADC failure	Analog to digital converter failure	Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*
E301	Audio alarm failure	Piezo is off but sensed on or Piezo is on but sensed off	Turn power off, then on, to reset the infuser Replace piezo alarm *(see Section 7.2.12.5)* Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*
E302	Backlight failure	Backlight (CCFT tube) is not at the expected range	Turn power off, then on, to reset the infuser Replace display *(see Section 7.2.12.3)* Reset time and date, if required *(see Section 1.8.3)*

Table 6-3. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E320	Battery charge current out of range	Battery charge current is out of range after 8 hours	Replace battery *(see Section 7.2.4)* Replace power supply PWA *(see Section 7.2.12.1)* Reset time and date, if required *(see Section 1.8.3)*
E321	Battery not charging	Battery charging timed out Complete battery discharge has occurred	Charge battery for additional 8 hours Replace battery *(see Section 7.2.4)* Replace power supply PWA *(see Section 7.2.12.1)* Reset time and date, if required *(see Section 1.8.3)*
E322	Battery current calibration value out of range	Battery integrator calibration value is out of range	
E323	Battery trickle charge current out of range	Battery trickle charge current is out of range	
E324	Supply overvoltage	An overvoltage condition is detected in the charging circuit	
E325	Battery overvoltage	An overvoltage condition is detected in the battery	
E326	Battery disconnected	Battery disconnected while the infuser is on	Check for loose battery connections Replace battery *(see Section 7.2.4)* Reset time and date, if required *(see Section 1.8.3)*
E327	Brownout condition	Brownout condition detected	Replace power supply PWA *(see Section 7.2.12.1)* Reset time and date, if required *(see Section 1.8.3)*
E340	Critical instruction failure	Power-up CPU register test failed (no malfunction message displayed)	Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*
E341	Critical data memory failure	Critical data memory failure	Replace mechanism assembly *(see Section 7.2.12.6)* Reset time and date, if required *(see Section 1.8.3)*

Table 6-3. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E342	Display failure	Defective display	Replace display assembly *(see Section 7.2.12.3)* Reset time and date, if required *(see Section 1.8.3)*
E343	Distal air sensor failure 1	With the cassette removed, the distal air sensor self test detects liquid	Replace mechanism assembly *(see Section 7.2.12.6)* Reset time and date, if required *(see Section 1.8.3)*
E344	Distal air sensor failure 2	With the cassette inserted, the distal air sensor self test detects sensor out of range	
E345	Distal pressure sensor failure 1	Distal pressure sensor failed while the infuser is off	
E346	Distal pressure sensor failure 2	Distal pressure sensor failed while the infuser is on	
E347	Hardware watchdog failure	Hardware watchdog failure	Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*
E378	I/O valve phase loss	Generic I/O valve failure	Turn power off, then on, to reset the infuser Replace mechanism assembly *(see Section 7.2.12.6)* Reset time and date, if required *(see Section 1.8.3)*
E379	L/S valve phase loss	Generic L/S valve failure	Turn power off, then on, to reset the infuser
E380	Plunger motor phase loss	Generic plunger motor failure	Replace mechanism assembly *(see Section 7.2.12.6)* Reset time and date, if required *(see Section 1.8.3)*

Table 6-3. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E430	Proximal air sensor failure 1	Proximal air sensor ongoing test detects liquid with cassette removed	Replace mechanism assembly *(see Section 7.2.12.6)* Reset time and date, if required *(see Section 1.8.3)*
E431	Proximal air sensor failure 2	Proximal air sensor self test detects liquid with cassette removed	
E432	Proximal pressure sensor 1	Proximal pressure sensor failed while the infuser is off	
E433	Proximal pressure sensor 2	Proximal pressure sensor failed while the infuser is on	
E434	RAM failure	RAM failure	Turn power off, then on, to reset the infuser Replace peripheral assembly *(see Section 7.2.6)* Reset time and date, if required *(see Section 1.8.3)*
E435	RTC failure	Real-time clock failure	Turn power off, then on, to reset the infuser Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*
E436	ROM failure	ROM checksum failure	Turn power off, then on, to reset the infuser Replace peripheral assembly *(see Section 7.2.6)* Reset time and date, if required *(see Section 1.8.3)*
E437	Software failure	Generic software failure	Turn power off, then on, to reset the infuser Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*
E438	Stack out-of-range failure	Stack out-of-range failure	

Table 6-3. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E439	Stuck key	A key is sensed as pressed for over two minutes	Replace keypad *(see Section 7.2.12.2)*
E440	Power hold stuck	Power hold signal stuck Power cannot be turned off	Reset time and date, if required *(see Section 1.8.3)*
E443	LCD failure	LCD bias is out of range	Replace display assembly *(see Section 7.2.12.3)* Reset time and date, if required *(see Section 1.8.3)*
E444	CPU timebase inaccurate	CPU timer 2 and RTC measured times disagree	Turn power off, then on, to reset the infuser Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*
E445	RTC memory failure	Real-time clock memory is corrupt	Turn power off, then on, to reset the infuser Reset time and date, if required *(see Section 1.8.3)*
E446	CPU timer failure	CPU timer 1 and timer 2 measured times disagree	Replace CPU PWA *(see Section 7.2.12.4)*
E447	Battery ADC reading failure	16 consecutive readings have been either all zero or the max value	Reset time and date, if required *(see Section 1.8.3)*
E448	SEEP write failure	SEEP data write failed	Replace mechanism assembly *(see Section 7.2.12.6)*
E449	SEEP calibration data corrupted	Calibration data block corrupted	Replace CPU PWA *(see Section 7.2.12.4)* Replace CPU/driver cable *(see Section 7.2.12.6)* Reset time and date, if required *(see Section 1.8.3)*
E450	MMIO port read/write failure	I/O port read/write failure	Replace CPU PWA *(see Section 7.2.12.4)* Reset time and date, if required *(see Section 1.8.3)*

Table 6-3. Error Codes Requiring Technical Service

Error Code	Malfunction	Possible Cause	Corrective Action
E451	Inaccurate delivery	Over/under delivery detected	Turn power off, then on, to reset the infuser Reset time and date, if required *(see Section 1.8.3)* If error codes recur, contact Hospira
E452	Software failure	Miscellaneous software failures	
E453	Two SEEP CRC errors	NVRAM data block corrupted	Replace mechanism assembly *(see Section 7.2.12.6)* Replace CPU PWA *(see Section 7.2.12.4)* Replace CPU/driver cable *(see Section 7.2.12.6)* Reset time and date, if required *(see Section 1.8.3)*
E454	NVRAM over capacity	Software trying to write into non-existent NVRAM space	
E455	Invalid device configuration	Incorrect flash memory on peripheral PWA	Turn power off, then on, to reset the infuser Replace peripheral assembly *(see Section 7.2.6)*
E456	Invalid drug library	A drug library install was started but not completed successfully	Attempt to reinstall the drug library *(see the system operating manual)* Replace peripheral assembly *(see Section 7.2.6)*
E457	Drug library corrupted	CRC failure on drug library	Reload the library *(see the system operating manual)*

Note: The following error codes are not generated in the biomed service mode:

E320	**E323**	**E326**	**E346**	**E373**	**E376**	**E379**	**E431**	**E441**
E321	**E324**	**E343**	**E371**	**E374**	**E377**	**E380**	**E432**	**E447**
E322	**E325**	**E345**	**E372**	**E375**	**E378**	**E430**	**E433**	

Note: Some error codes include sub-ID codes. These sub-ID codes are intended for Hospira internal use only, and should be included when contacting Hospira Technical Support Operations *(see Section 6.1)*.

6.4 TROUBLESHOOTING PROCEDURES

This section details recommended procedures for problems not associated with malfunction alarms. Before performing any troubleshooting procedure, turn the infuser off, then on.

Allow the self test to complete and proceed as follows:

1. If a malfunction exists, carefully inspect the infuser for damage as described in *Section 5.2.2*.
2. If an infuser inspection has not disclosed a malfunction, perform the PVT in *Section 5.2*. See *Table 6-4* for section reference, probable cause, and corrective actions.
3. If, after completing step 1 and step 2, a malfunction has not been located, or if the infuser persistently fails, contact Hospira *(see Section 6.1)*.

Table 6-4. Troubleshooting with the PVT

Test Failure	Probable Cause	Corrective Action
Self test *Section 5.2.4*	Cassette not properly installed	Reseat cassette
	Defective CPU PWA	Replace CPU PWA *(see Section 7.2.12.4)*
Cassette alarm test *Section 5.2.5*	Cassette not properly seated	Reseat cassette
	Defective cassette	Replace cassette
Free flow test *Section 5.2.6*	Cassette not properly seated	Reseat cassette
	Defective cassette	Replace cassette
	Defective or dirty valve pins	Clean valve pins
		Replace mechanism assembly *(see Section 7.2.12.6)*
Display test *Section 5.2.7*	Defective display assembly	Replace display assembly *(see Section 7.2.12.3)*
Keypad verification/ functional test *Section 5.2.8*	Defective keypad	Replace keypad *(see Section 7.2.12.2)*
Alarm loudness test *Section 5.2.9*	Defective CPU	Replace CPU PWA *(see Section 7.2.12.4)*
	Defective peripheral PWA	Replace peripheral assembly *(see Section 7.2.6)*
	Defective piezo alarm assembly	Replace piezo alarm assembly *(see Section 7.2.12.5)*

Table 6-4. Troubleshooting with the PVT		
Test Failure	**Probable Cause**	**Corrective Action**
Lockout switch test *Section 5.2.10*	Defective peripheral PWA	Replace peripheral assembly *(see Section 7.2.6)*
Proximal occlusion test *Section 5.2.11*	Closed proximal clamp	Open clamp
	Cassette not properly primed	Re-prime cassette
	Defective cassette	Replace cassette
	Dirty sensor pin	Clean sensor pin
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.12.6)*
Proximal air-in-line test *Section 5.2.12*	Defective special cassette	Replace special cassette
	Dirty sensors	Clean sensors
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.12.6)*
Distal air-in-line test *Section 5.2.13*	Defective special cassette	Replace special cassette
	Dirty sensors	Clean sensors
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.12.6)*
Distal occlusion test *Section 5.2.14*	Cassette not properly primed	Re-prime cassette
	Defective cassette	Replace cassette
	Dirty sensor pin	Clean sensor pin
	Defective APP PWA	Replace mechanism assembly *(see Section 7.2.12.6)*
Delivery accuracy test *Section 5.2.15*	Set not properly primed	Re-prime cassette
	Damaged or faulty cassette	Replace cassette
	Defective mechanism assembly	Replace mechanism assembly *(see Section 7.2.12.6)*
Electrical safety test *Section 5.2.17*	Defective AC power cord	Replace AC power cord *(see Section 7.2.5)*

Section 7

REPLACEABLE PARTS AND REPAIRS

This section itemizes all parts and subassemblies of the infusion system that are repairable within the scope of this manual. In addition, this section details replacement procedures for all listed parts.

7.1 REPLACEABLE PARTS

Replaceable parts for the infuser are itemized in the spare parts price list and are identified in *Figure 9-1*. *Table 9-2* identifies each part by an index number that correlates to *Figure 9-1*.

To request a copy of the current spare parts price list, contact Hospira Technical Support Operations *(see Section 6.1)*, or to view the catalog online, visit the website at:

www.hospiraparts.com

For convenient reference, insert a copy of the spare parts price list here.

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7.2 REPLACEMENT PROCEDURES

This section contains safety and equipment precautions, required tools and materials, and step-by-step procedures for replacing parts in the infuser. Unless otherwise stated, always perform the PVT after a replacement procedure.

7.2.1 SAFETY AND EQUIPMENT PRECAUTIONS

Before opening the front enclosure of the infuser, take all necessary precautions for working on high-voltage equipment.

WARNING: POSSIBLE EXPLOSION HAZARD EXISTS IF THE INFUSER IS SERVICED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

WARNING: UNLESS OTHERWISE INDICATED, DISCONNECT THE INFUSER FROM AC POWER BEFORE PERFORMING ADJUSTMENTS OR REPLACEMENT PROCEDURES.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

7.2.2 REQUIRED TOOLS AND MATERIALS

The following tools and materials, or equivalents, are required for the replacement procedures in this section. In addition, the beginning of each procedure lists tools and materials recommended for that specific procedure.

- Set of flat blade screwdrivers
- Set of Phillips® screwdrivers
- Set of standard and metric nutdrivers
- Metric 10 mm wrench
- Custom nutdriver (P/N 519-95056-001)
- Long needle nose pliers
- Wide-head pliers
- Diagonal cutters
- X-acto® knife
- Mild solvent
- Lint-free cloth

7.2.3
RUBBER FOOT PAD REPLACEMENT

Recommended tools for this procedure are an X-acto knife, mild solvent, and lint-free cloth.

The replacement part for this procedure is:

Pad, Rubber Foot

To replace the rubber foot pad, see *Figure 7-1*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Place the infuser on its side.
3. Using the X-acto knife, remove the rubber foot pad and scrape the enclosure recess to remove adhesive residue.

   Note: Each adhesive-backed rubber foot pad is bonded in its recess. Do not damage the recess.

4. Using mild solvent and a lint-free cloth, clean any adhesive residue from the enclosure recess.
5. Remove the protective backing from the self-adhesive surface of the replacement foot pad and press the pad in place.
6. After approximately five minutes, verify the foot pad is secure.

Replacement of a rubber foot pad is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during a rubber foot pad replacement, perform the PVT in *Section 5.2*.

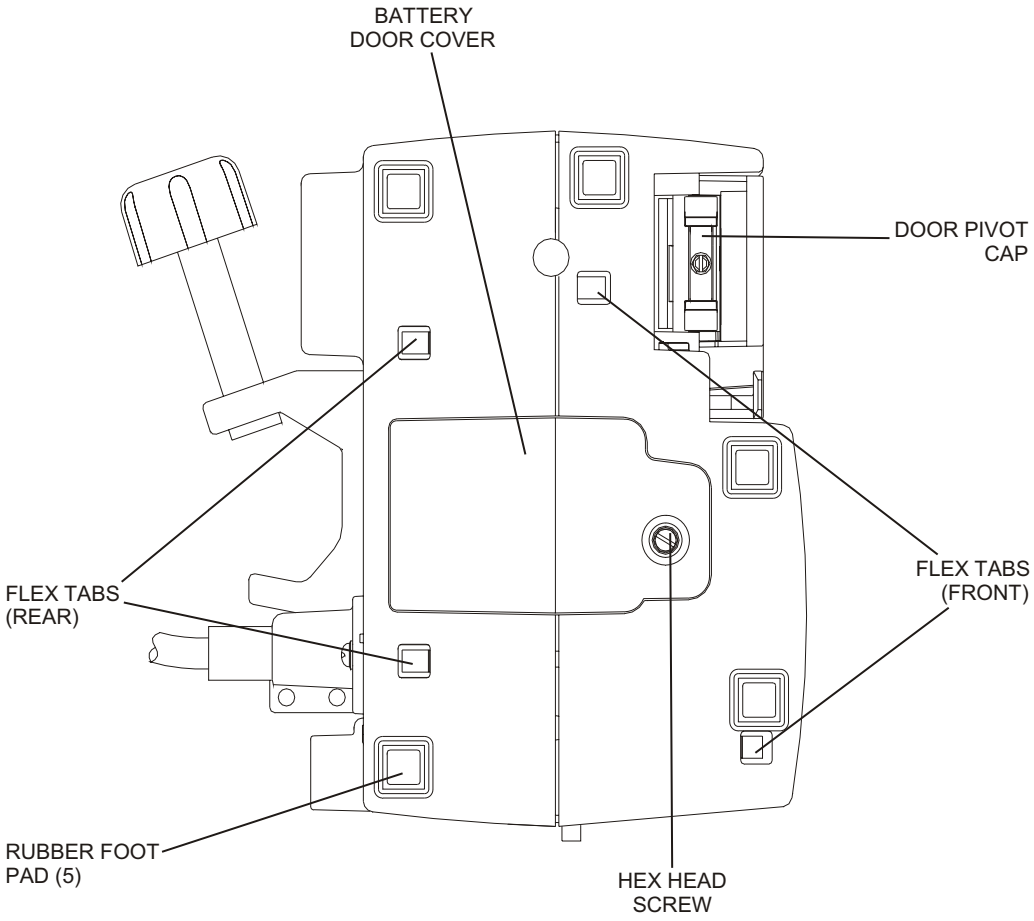

Figure 7-1. Bottom View

7.2.4
BATTERY, BATTERY DOOR, AND DOOR PAD REPLACEMENT

Recommended tools for this procedure are a medium size flat blade screwdriver, mild solvent, and a lint-free cloth.

The replacement parts for this procedure are:

Assembly, Battery, with Wire Harness
Door, Battery
Pad, Door
Gasket, Battery
Screw, 6-32 x 3/8, Hex Head, Slotted, with Washer

To replace the battery, battery door, and door pad, see *Figure 7-2*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Place the infuser on its side.
3. Using the flat blade screwdriver, remove the screw that attaches the battery door to the infuser, and remove the door.
4. Inspect the battery door, gasket, and door pad for damage. Replace the door, if required.
5. If the door pad is defective, remove it and clean the door with mild solvent. Dry the battery door thoroughly, and install the replacement pad onto the door.
6. Remove and inspect the gasket from the battery door. Remove the adhesive from the replacement gasket and install the gasket in the battery door.

   Note: The gasket may not be present on earlier versions of the Plum A+®.

7. Disconnect the battery harness from the charger circuit cable. Carefully pull the battery harness wires and connector outside the enclosure, and remove the battery.
8. Connect the replacement battery harness to the charger circuit cable, and insert the replacement battery into the enclosure.

   Note: The cable connectors are keyed so that cables cannot be connected incorrectly.

   Note: Confirm the battery harness is not pinched between the battery and the enclosure.

9. Replace the battery door using the screw that was removed in step 3.
10. Press [ON/OFF] with the infuser disconnected from AC power, and verify the front panel battery symbol illuminates.
11. Access the **BIOMED SETTINGS** screen and press [CHANGE BATTERY].

    Note: The [CHANGE BATTERY] softkey will not appear on earlier versions of the Plum A+®.

Replacement of the battery, battery door, and door pad is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during these procedures, perform the PVT in *Section 5.2*.

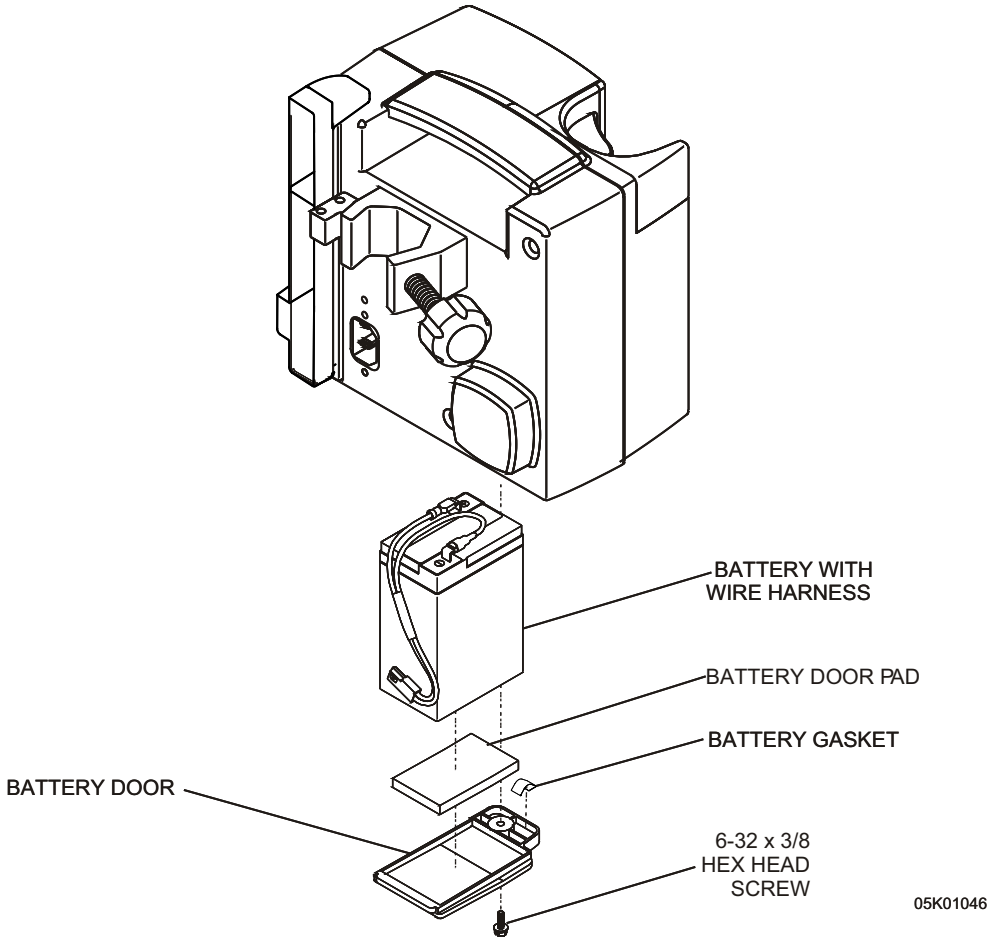

Figure 7-2. Battery, Battery Door, and Door Pad

7.2.5
AC POWER CORD, RETAINER, AND VELCRO STRAP REPLACEMENT

The recommended tools for this procedure are a #2 Phillips screwdriver and a 10 mm wrench.

The replacement parts for this procedure are:

Cordset, AC Power, Hospital Grade, Detachable
Retainer, AC Power Cord
Strap, Velcro, AC Power Cord
Terminal, Equipotential
Screw, 4-40 x 1/4, Pan Head, Phillips
Screw, 6-32 x 5/8, Pan Head, Phillips, with Washer
Screw, Jack, 4-40 x 7/16
Washer, Flat, #4
Washer, Lock, #4

To replace the AC power cord, retainer, and Velcro strap, see *Figure 7-3*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Using the Phillips screwdriver, remove the screws from the AC power cord retainer.
4. Using the 10 mm wrench, remove and inspect the equipotential terminal, and replace, if required.
5. Unplug the power cord, and slide the plug through the retainer.

   Note: Remove the AC power cord from its receptacle by grasping the plug. Do not pull the cord.

6. Remove the Velcro strap from the power cord. Inspect the Velcro strap for wear and replace the strap, if required. Attach the strap to the replacement power cord.
7. Install the replacement AC power cord in the exact reverse order of removal.
8. Reinstall the battery and connect the device to AC power.
9. Press [ON/OFF] and verify the infuser powers on.

Replacement of the AC power cord, retainer, and Velcro strap is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during these procedures, perform the PVT in *Section 5.2*.

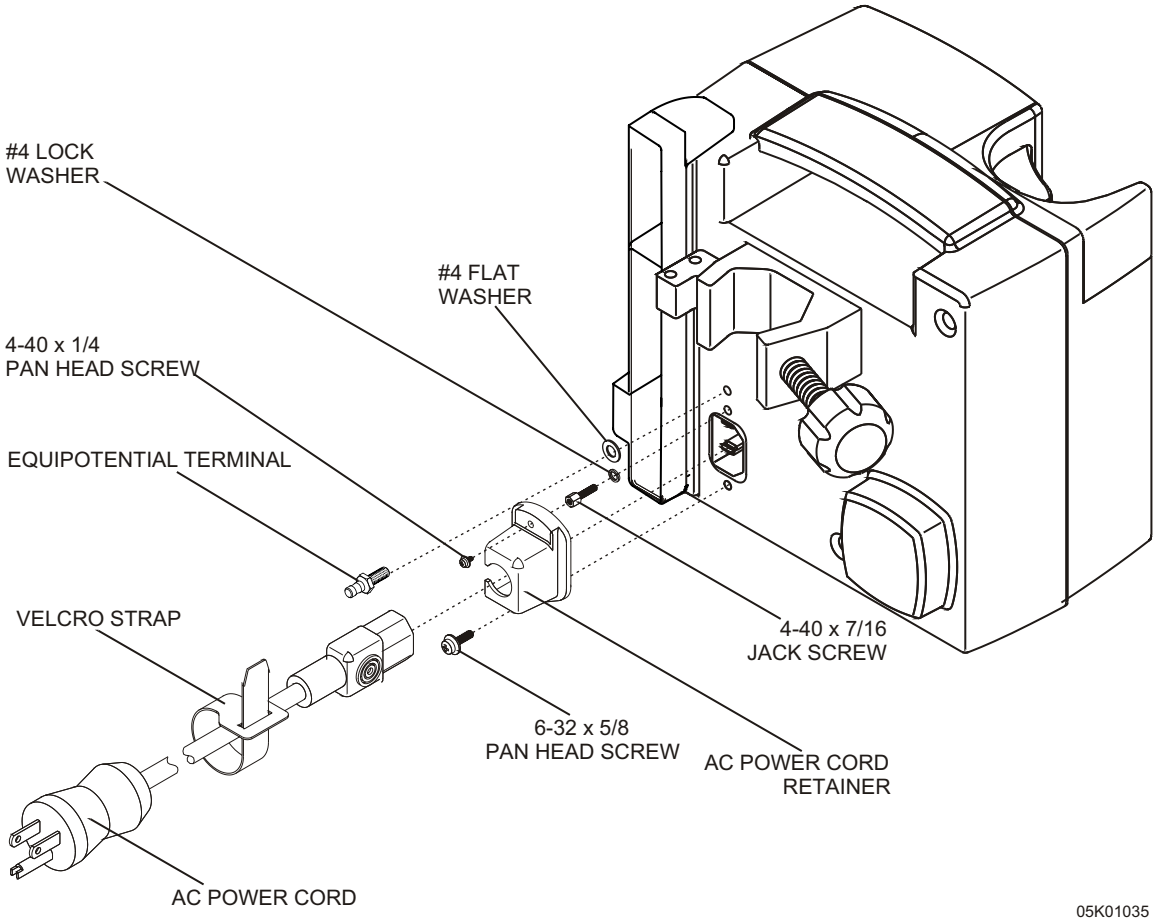

Figure 7-3. AC Power Cord, Retainer, and Velcro Strap

7.2.6
PERIPHERAL ASSEMBLY REPLACEMENT

CAUTION: Peripheral assembly replacement should only be performed after receiving approval from Hospira Technical Support Operations *(see Section 6.1)*.

The recommended tool for this procedure is a #2 Phillips screwdriver.

The replacement parts for this procedure are:

Assembly, Peripheral
Screw, 4-40 x 1/2, Pan Head, Square Cone, Phillips

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

Note: Replacing the peripheral assembly does not change the existing biomed settings.

To replace the peripheral assembly, see *Figure 7-4* and *Figure 7-5*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Carefully set the infuser face down.
4. Using the Phillips screwdriver, remove the two screws from the peripheral assembly.
5. Carefully pull the assembly away from the infuser.

   Note: When removing the peripheral assembly, note the placement guides where the peripheral interface PWA rests.

6. Install the replacement peripheral assembly in the exact reverse order of removal.

   Note: Verify the peripheral assembly is placed properly between the guides and fits correctly into the CPU PWA.

7. Reinstall the battery and connect the device to AC power.
8. Turn on the infuser, and verify completion of the self test.

To verify successful peripheral assembly replacement, perform the PVT in *Section 5.2*.

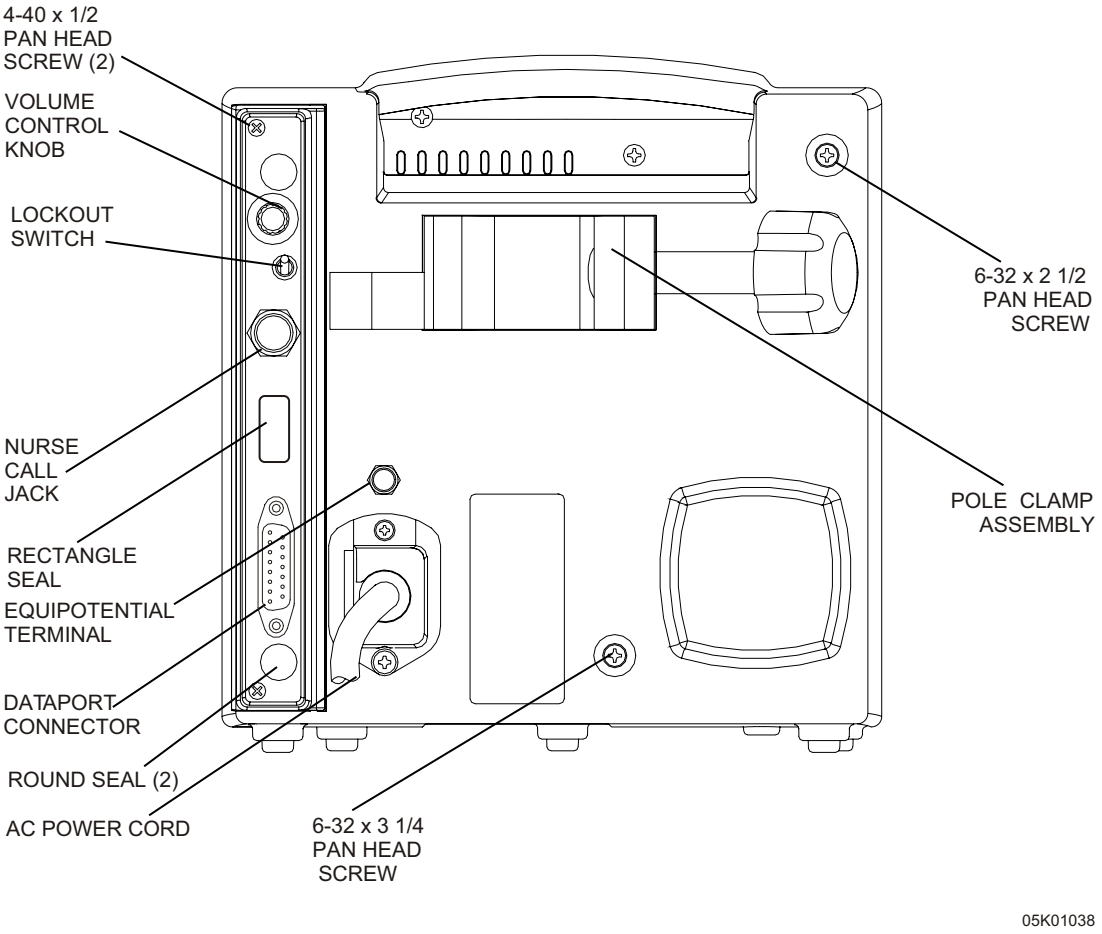

Figure 7-4. Rear View

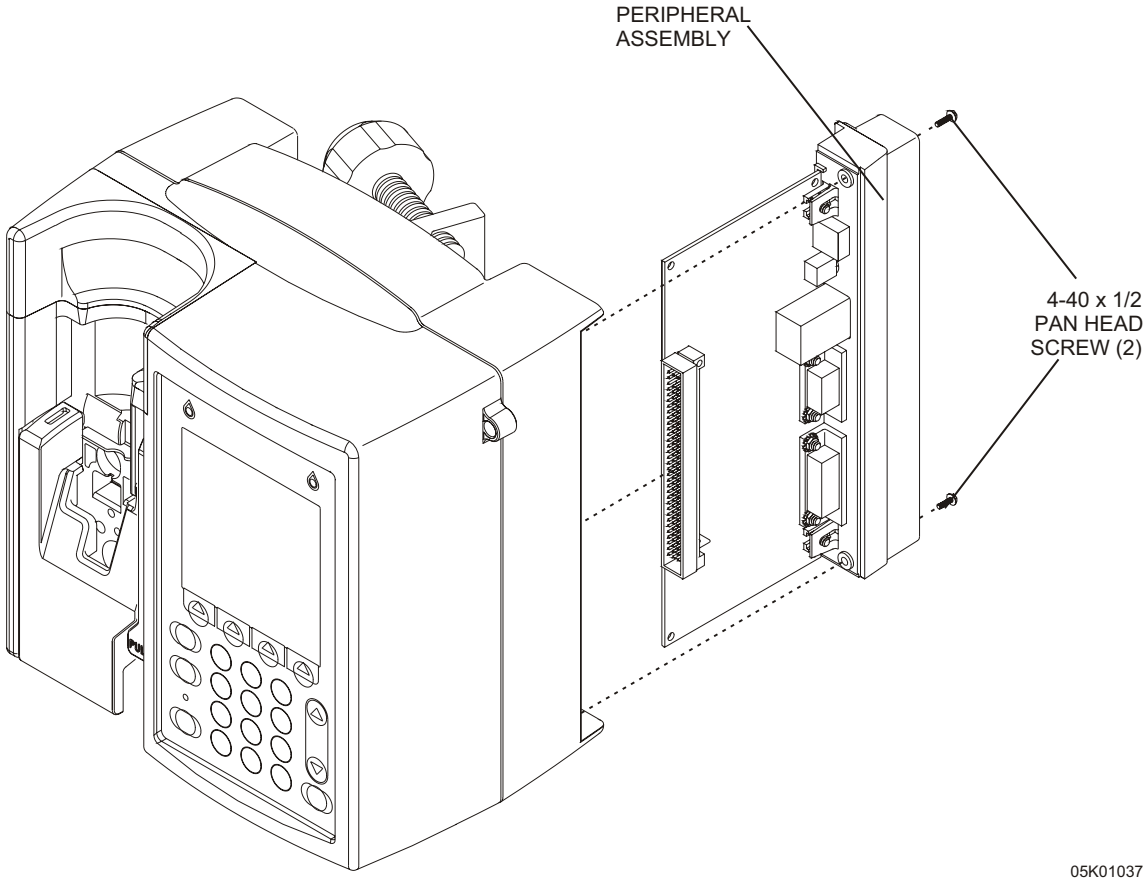

Figure 7-5. Peripheral Assembly Replacement

7.2.7
PERIPHERAL ASSEMBLY COMPONENT REPLACEMENT

Peripheral assembly component replacement includes the replacement of the volume control knob and the peripheral cover.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the peripheral assembly components, see *Figure 7-6*, then proceed as detailed in the following sections.

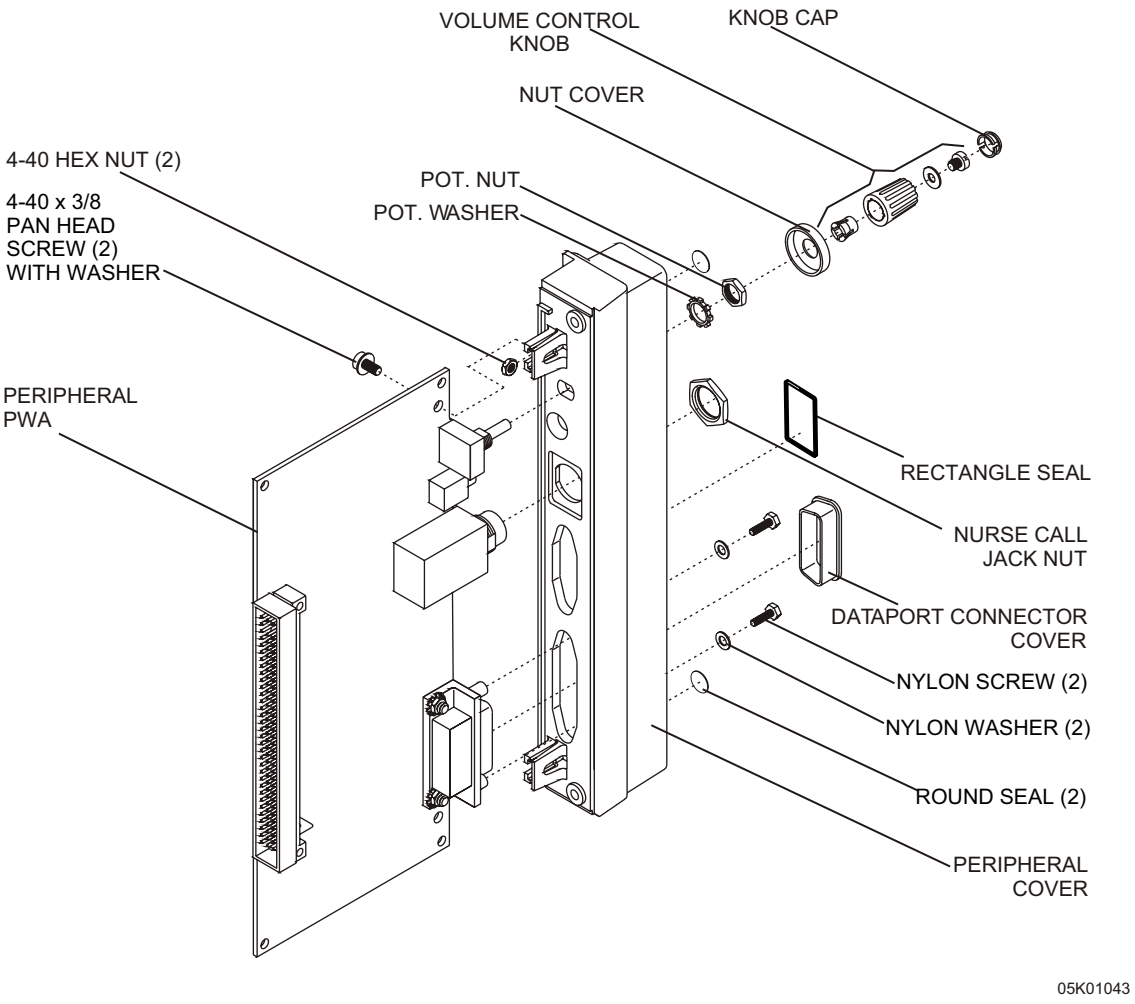

Figure 7-6. Peripheral Assembly Components

7.2.7.1
VOLUME CONTROL KNOB REPLACEMENT

Recommended tools for this procedure are an X-acto knife, a medium size flat blade screwdriver, and long needle nose pliers.

The replacement parts for this procedure are:

Assembly, Volume Control Knob
Cap, Knob
Cover, Nut

To replace the volume control knob, see *Figure 7-4* and *Figure 7-6*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Carefully set the infuser face down.
4. Remove the peripheral assembly as described in *Section 7.2.6*.
5. Using the X-acto knife, lift the volume control knob end cap away from the knob, exposing a flat head screw.
6. Using the flat blade screwdriver, remove the screw that secures the knob.
7. Using long needle nose pliers, remove the volume control knob.
8. Install the replacement volume control knob in the exact reverse order of removal.
9. Replace the peripheral assembly in the exact reverse order of removal.
10. Reinstall the battery and connect the device to AC power.

To verify successful volume control knob replacement, perform the PVT in *Section 5.2*.

7.2.7.2
PERIPHERAL COVER REPLACEMENT

Recommended tools for this procedure are a 5/16 nutdriver, custom nutdriver, long needle nose pliers, and a #2 Phillips screwdriver.

The replacement parts for this procedure are:

Cover, Peripheral
Cover, DataPort Connector
Seal, Rectangle
Seal, Round
Screw, 4-40 x 3/8, Hex Head, Nylon
Screw, 4-40 x 3/8, Pan Head, Phillips, with Washer
Washer, Flat, .128 Dia., Nylon
Nut, Hex, Nurse Call Jack
Nut, Hex, 4-40

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the peripheral cover, see *Figure 7-6*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Carefully set the infuser face down.
4. Remove the peripheral assembly as described in *Section 7.2.6*.
5. Remove the volume control knob as described in *Section 7.2.7.1*.
6. Using the 5/16 nutdriver, remove the nut that secures the potentiometer to the peripheral cover. Using the needle nose pliers, remove the lock washer.
7. Using the custom nutdriver, remove the hex nut that secures the nurse call jack to the peripheral cover.
8. Remove and inspect the DataPort connector cover and replace, if required.
9. Inspect the seals and replace, if required.
10. Using the Phillips screwdriver, remove the screws that secure the peripheral PWA to the cover.
11. Install the replacement peripheral cover in the exact reverse order of removal.
12. Install the volume control knob and nurse call jack nut in the exact reverse order of removal.
13. Install the peripheral assembly as described in *Section 7.2.6*.
14. Reinstall the battery and connect the device to AC power.
15. Turn on the infuser, and verify completion of the self test.

7.2.8
SEPARATING THE FRONT ENCLOSURE, REAR ENCLOSURE, AND MAIN CHASSIS ASSEMBLY

The recommended tools for this procedure are a #2 Phillips screwdriver, medium size flat blade screwdriver, and 3/16 nutdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

To separate the front enclosure, rear enclosure, and main chassis assembly, see *Figure 7-7*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Using the Phillips screwdriver, remove the screws from the peripheral assembly and carefully pull the assembly away from the infuser *(see Section 7.2.6)*.
3. Remove the battery as described in *Section 7.2.4*.
4. Remove the AC power cord and retainer, and the equipotential terminal as described in *Section 7.2.5*.
5. Using the 3/16 nutdriver, remove the jack screw and lock washer *(see Figure 7-3)*.
6. Using the Phillips screwdriver, remove the remaining screws from the upper right corner and lower center of the rear enclosure.
7. Carefully place the infuser face down.
8. Using the flat blade screwdriver, depress the two flex tabs that secure the rear enclosure while lifting up the rear enclosure. Remove the rear enclosure.

9. Using the Phillips screwdriver, remove the screws in the infuser handle, and remove the shoe from the front enclosure.
10. Carefully place the infuser face up.
11. Using the flat blade screwdriver, depress the flex tabs that secure the front enclosure while lifting up the front enclosure, and remove the front enclosure.

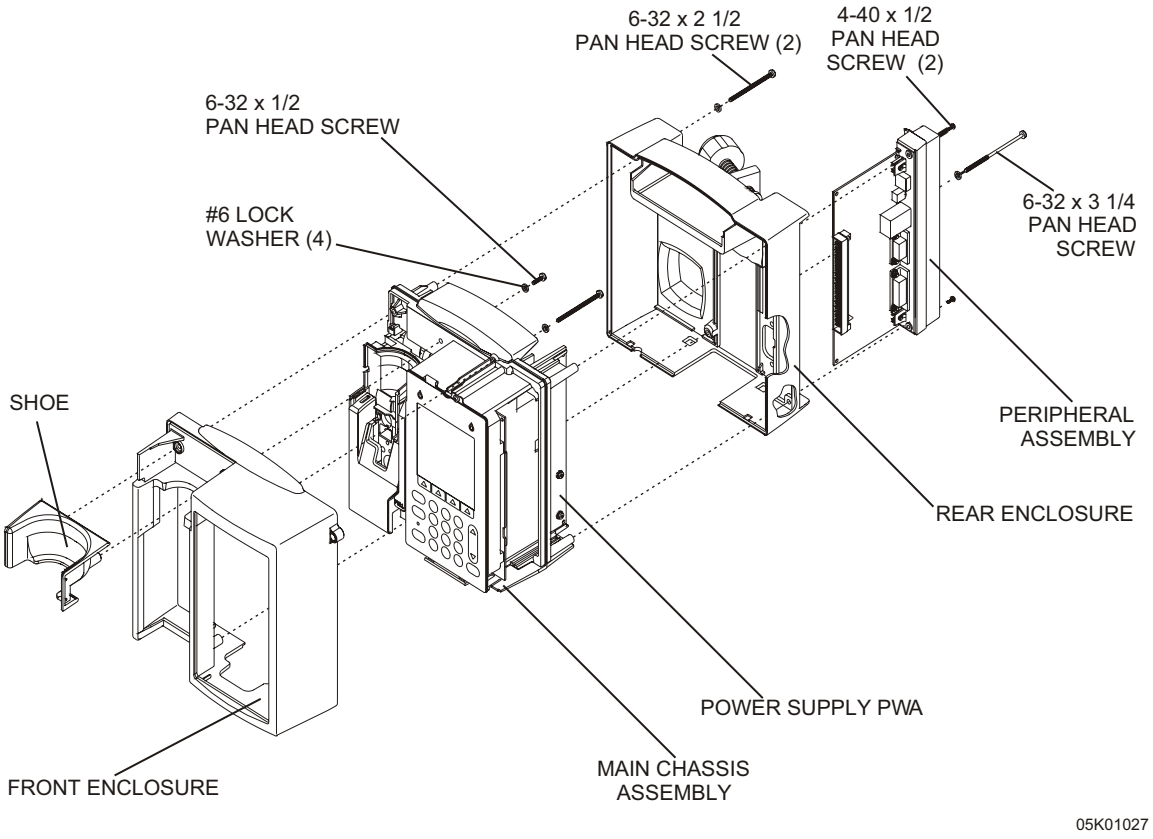

Figure 7-7. Separating the Front Enclosure, Main Chassis, and Rear Enclosure

7.2.9
FRONT ENCLOSURE, REAR ENCLOSURE, OR MAIN CHASSIS ASSEMBLY REPLACEMENT

There are no recommended tools for this procedure.

Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

The replacement parts for this procedure are:

Enclosure, Front
Enclosure, Rear
Chassis, Main
Shoe, Front Enclosure
Screw, 6-32 x 1/2, Pan Head, Phillips
Screw, 6-32 x 2 1/2, Pan Head, Phillips
Screw, 6-32 x 3 1/4, Pan Head, Phillips
Washer, Lock, Helical, #6

To replace the front enclosure, rear enclosure, or main chassis assembly, see *Figure 7-7*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. To replace the front enclosure, remove the gaskets described in *Section 7.2.9.1* and *Section 7.2.9.2*.
5. To replace the rear enclosure, remove the specific components described in *Section 7.2.10*.
6. To replace the main chassis assembly, remove the specific components described in *Section 7.2.12*.
7. Reassemble the front enclosure, rear enclosure, or main chassis assembly components.

   Note: Assure the CPU/driver cable is positioned completely above and to the side of the battery enclosure prior to joining the rear enclosure to the main chassis.

8. Join the front enclosure, main chassis assembly, and rear enclosure in the exact reverse order of separation.
9. Reinstall the battery and connect the device to AC power.

To verify successful front enclosure, rear enclosure, or main chassis replacement, perform the PVT in *Section 5.2*.

7.2.9.1
SHOE GASKET REPLACEMENT

The recommended tool for this procedure is needle nose pliers.

The replacement part for this procedure is:

Gasket, Shoe

To replace the shoe gaskets, see *Figure 7-8*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Remove the shoe gaskets from the front and back of the front enclosure as shown in *Figure 7-8*.
5. Install the replacement shoe gaskets in the exact reverse order of removal.
6. Join the front enclosure, main chassis assembly, and rear enclosure in the exact reverse order of separation.
7. Reinstall the battery and connect the device to AC power.

To verify successful shoe gasket replacement, perform the PVT in *Section 5.2*.

7.2.9.2
FRONT/REAR ENCLOSURE GASKET REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Gasket, Front/Rear Enclosure

To replace the front/rear enclosure gaskets, see *Figure 7-8*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Remove the front/rear gasket from the front enclosure.
5. Install the replacement front/rear gasket in the exact reverse order of removal.
6. Join the front enclosure, main chassis assembly, and rear enclosure in the exact reverse order of separation.
7. Reinstall the battery and connect the device to AC power.

To verify successful front/rear enclosure gasket replacement, perform the PVT in *Section 5.2*.

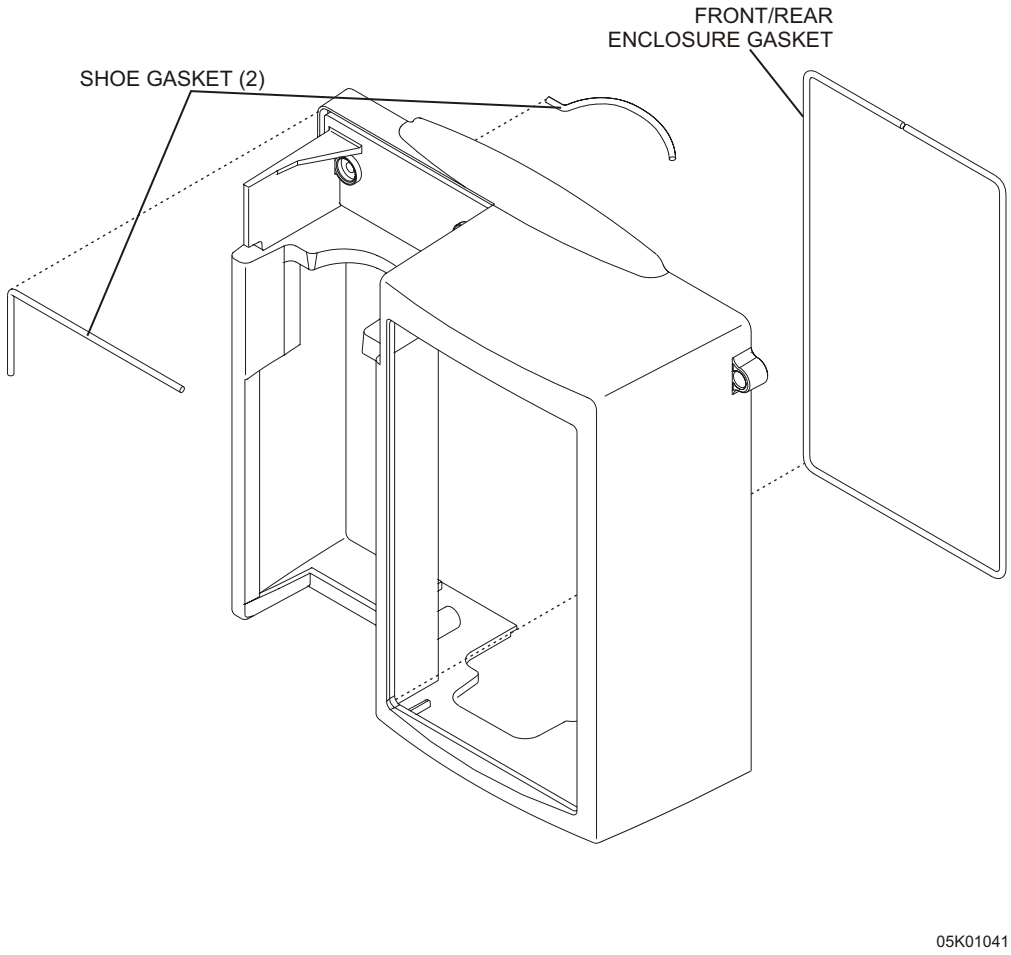

Figure 7-8. Front Enclosure Gaskets

7.2.10
REAR ENCLOSURE COMPONENT REPLACEMENT

Rear enclosure component replacement includes the replacement of the following:

- Pole clamp extrusion and backing plate
- Pole clamp shaft/knob assembly and shaft tip
- Rear enclosure and handle gaskets

To replace the rear enclosure components, see *Figure 7-9*, then proceed as detailed in the following sections.

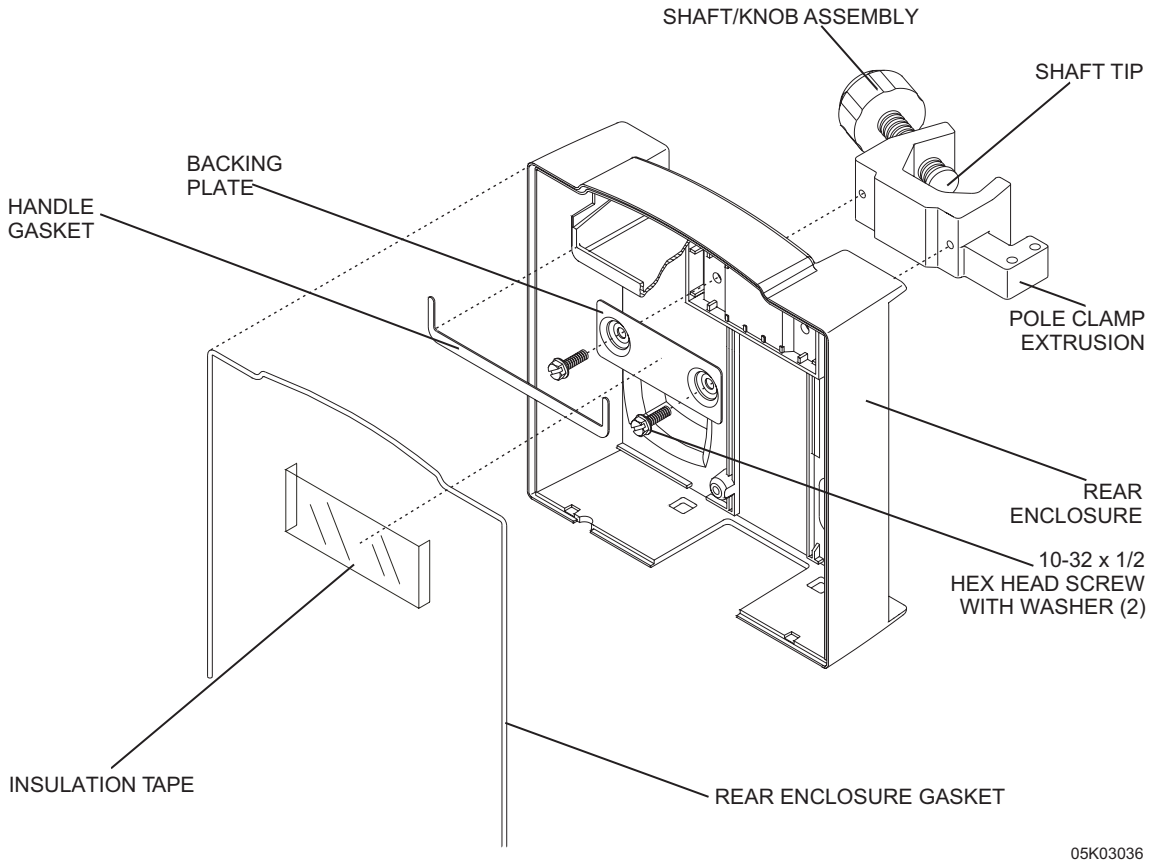

Figure 7-9. Rear Enclosure Components

7.2.10.1

POLE CLAMP EXTRUSION AND BACKING PLATE REPLACEMENT

Recommended tools for this procedure are a medium size flat blade screwdriver and mild solvent.

The replacement parts for this procedure are:

Extrusion, Pole Clamp
Plate, Backing, Pole Clamp
Tape, Insulation
Screw, 10-32 x 1/2, Hex Head, Slotted, with Washer

To replace the pole clamp extrusion and backing plate, see *Figure 7-9*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the rear enclosure from the main chassis assembly as described in *Section 7.2.8*.
4. Using the flat blade screwdriver, remove the screws that secure the pole clamp backing plate to the pole clamp extrusion, and remove the backing plate and pole clamp from the rear enclosure.
5. Install the replacement backing plate and extrusion, using the screws that were removed in step 4.
6. Completely cover the pole clamp backing plate with insulation tape. Press firmly to adhere the insulation tape to the backing plate.

   CAUTION: Assure the insulation tape covers the entire backing plate. If the backing plate is exposed, the power supply PWA may be damaged when power is applied to the infuser.

7. Join the rear enclosure and main chassis assembly in the exact reverse order of separation.
8. Reinstall the battery and connect the device to AC power.

To verify successful pole clamp extrusion and backing plate replacement, perform the PVT in *Section 5.2*.

7.2.10.2

POLE CLAMP SHAFT/KNOB ASSEMBLY AND SHAFT TIP REPLACEMENT

The recommended tool for this procedure is wide-head pliers.

The replacement parts for this procedure are:

Assembly, Shaft/Knob, Pole Clamp
Tip, Shaft, Pole Clamp

To replace the pole clamp shaft/knob assembly and the pole clamp shaft tip, see *Figure 7-9*, then proceed as follows:

1. Turn the pole clamp shaft/knob assembly counterclockwise to remove it from the pole clamp extrusion, and loosen the pole clamp shaft tip from the shaft/knob assembly.

   Note: The pole clamp shaft tip has a long shaft that is pressed into the threaded pole clamp shaft/knob assembly.

2. Turn the pole clamp shaft/knob assembly back into the pole clamp extrusion. Using the wide-head pliers, remove the pole clamp shaft tip and replace the tip, if necessary.
3. Install the replacement pole clamp shaft/knob assembly into the pole clamp extrusion by turning the shaft/knob assembly clockwise into the extrusion until the threaded portion is visible.
4. Press the pole clamp shaft tip into the screw hole recess on the shaft/knob assembly and turn the shaft/knob assembly clockwise until the shaft tip is secure against the pole clamp extrusion.

Replacement of the pole clamp shaft/knob assembly and the pole clamp shaft tip is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.10.3
REAR ENCLOSURE AND HANDLE GASKETS REPLACEMENT

There are no recommended tools for this procedure.

The replacement parts for this procedure are:

Gasket, Rear Enclosure
Gasket, Handle

To replace the rear enclosure and handle gaskets, see *Figure 7-9*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the rear enclosure and main chassis assembly as described in *Section 7.2.8*.
4. Remove the rear enclosure and handle gaskets from the rear enclosure assembly.
5. Install the replacement gaskets in the exact reverse order of removal.
6. Join the rear enclosure and main chassis assembly in the exact reverse order of separation.
7. Reinstall the battery and connect the device to AC power.

To verify successful rear enclosure and handle gaskets replacement, perform the PVT in *Section 5.2*.

7.2.11
MINIPOLE ASSEMBLY REPLACEMENT

The minipole assembly attaches to the infuser through two holes in the heatsink and is held in place by a cotter ring. This cotter ring passes through a hole near the end of the longer of the two vertical rods on the bag hanger and prevents the removal of the minipole assembly from the holes in the pole clamp *(see Figure 7-10)*.

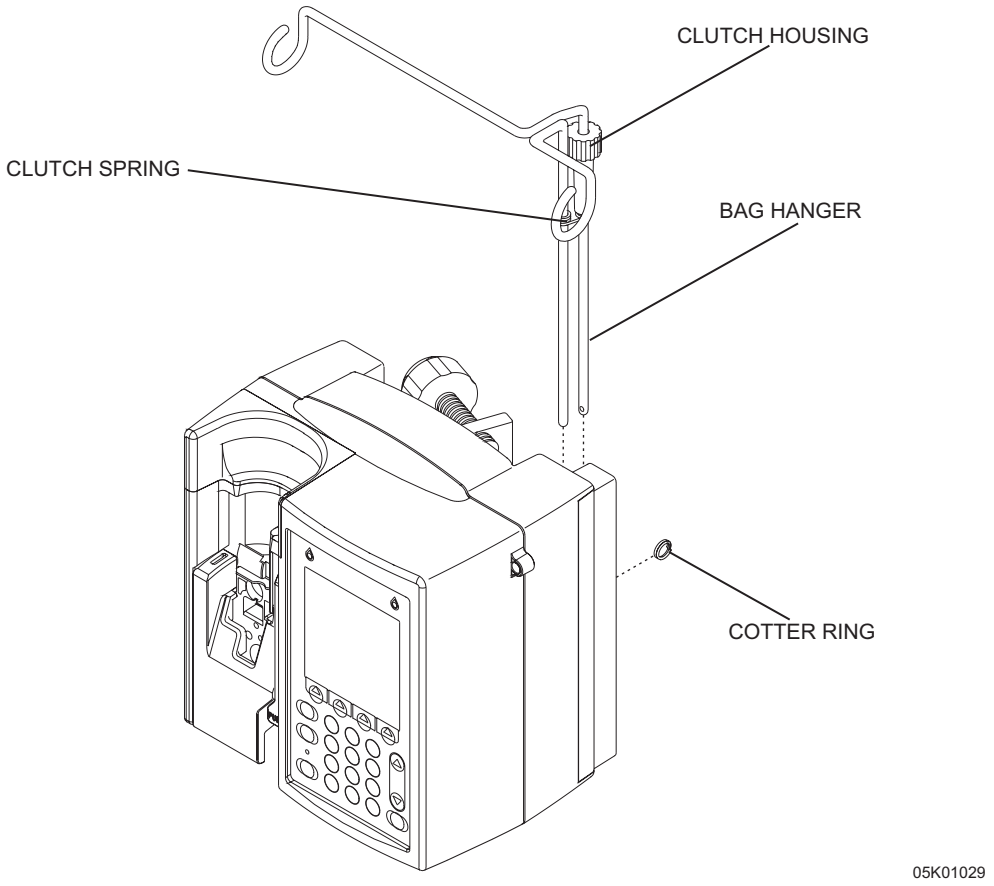

Figure 7-10. Minipole Assembly

7.2.11.1
COTTER RING REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Ring, Cotter, Minipole

To replace the cotter ring, see *Figure 7-10*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Place the infuser face down on a soft surface.

3. Grasp the cotter ring with thumb and finger. Twist, rotate, and remove the cotter ring from the rod hole.
4. Replace the cotter ring in the exact reverse order of removal.

Replacement of the cotter ring is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the replacement procedure, perform the PVT as described in *Section 5.2*.

7.2.11.2
BAG HANGER REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Hanger, Bag, Minipole

To replace the bag hanger, see *Figure 7-10*, then proceed as follows:

1. Remove the cotter ring as described in *Section 7.2.11.1*.
2. Remove the bag hanger from the pole clamp rod holes.
3. Insert the replacement bag hanger in the pole clamp rod holes.
4. Insert the cotter ring.

Replacement of the bag hanger is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.11.3
CLUTCH HOUSING REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Housing, Clutch, Minipole

To replace the clutch housing, see *Figure 7-10*, then proceed as follows:

1. Remove the bag hanger from the infuser as described in *Section 7.2.11.2*.
2. Turn the clutch housing knob counterclockwise to loosen the clutch spring, and slide the knob and spring downward to remove them.
3. Work the clutch spring free from the clutch housing hole and install it into the replacement clutch housing.
4. Install the replacement clutch housing by turning the clutch housing knob counterclockwise and sliding it up the short rod. Confirm the clutch spring slides up the long rod.
5. Install the cotter ring.

Replacement of the clutch housing is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.11.4
CLUTCH SPRING REPLACEMENT

There are no recommended tools for this procedure.

The replacement part for this procedure is:

Spring, Clutch, Minipole

To replace the clutch spring, see *Figure 7-10*, then proceed as follows:

1. Remove the clutch housing as described in *Section 7.2.11.3*.
2. Work the clutch spring free from the clutch housing hole and install the replacement clutch spring.

Replacement of the clutch spring is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.2.12
MAIN CHASSIS ASSEMBLY COMPONENT REPLACEMENT

Main chassis assembly component replacement includes the replacement of the following:

- Power supply PWA
- CPU PWA
- Cassette door
- Keypad
- Piezo alarm assembly
- Fluid shield
- Display assembly
- Mechanism assembly
- Opener handle assembly

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.

To replace the main chassis assembly components, see *Figure 7-11*, then proceed as detailed in the following sections.

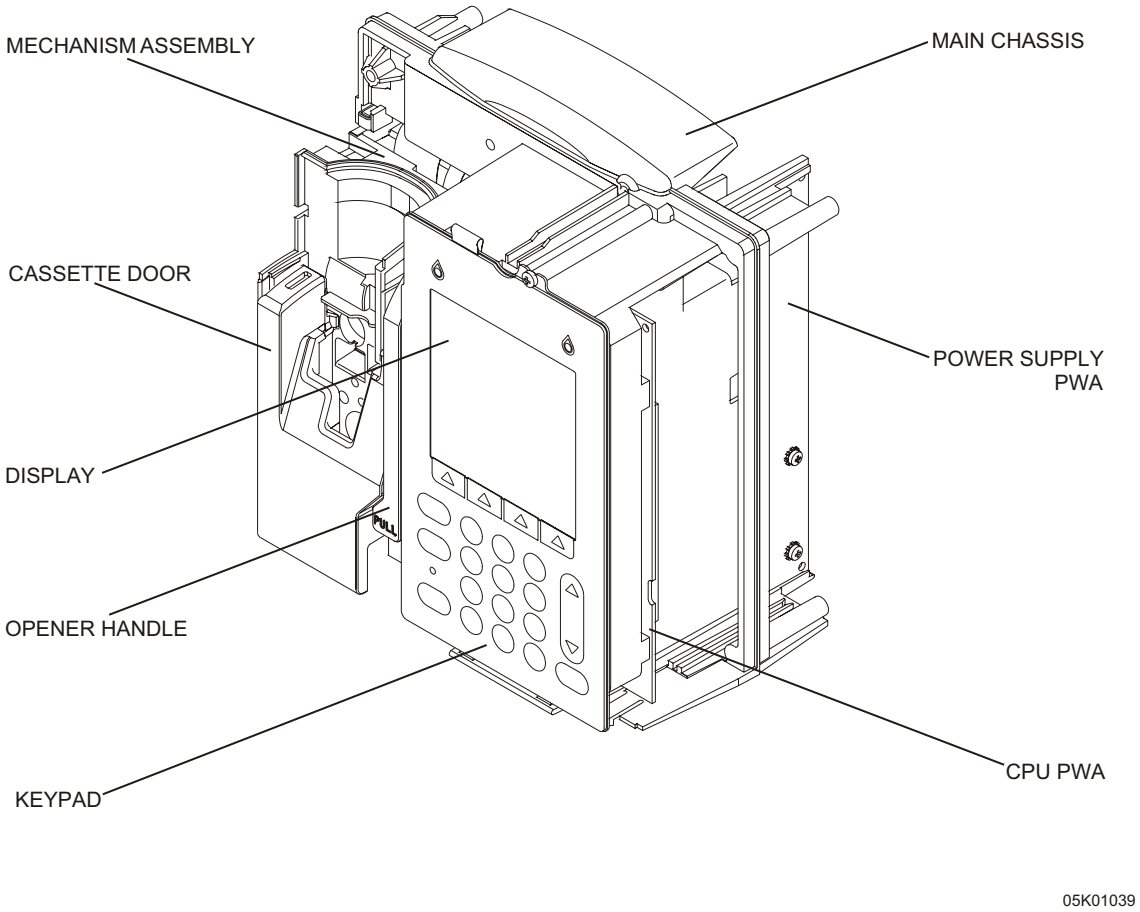

Figure 7-11. Main Chassis Assembly Components

7.2.12.1
POWER SUPPLY PWA REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

The replacement parts for this procedure are:

PWA, Power Supply
Assembly, Cable, Power Supply/Battery
Assembly, Cable, Power Supply/Driver

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the power supply PWA, proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the rear enclosure from the main chassis as described in *Section 7.2.8*.
4. Disconnect the battery cable from the power supply PWA.
5. Disconnect the driver cable from the power supply PWA.
6. Remove the power supply PWA by sliding the board away from the CPU PWA.
7. Install the replacement power supply PWA in the exact reverse order of removal.

   Note: Verify the replacement power supply PWA connects to the CPU PWA correctly to avoid misalignment.

   Note: If an alarm sounds, press the [ON/OFF] key to deactivate the alarm.
8. Join the rear enclosure and main chassis assembly in the exact reverse order of separation.
9. Reinstall the battery and connect the device to AC power.

To verify successful power supply PWA replacement, perform the PVT in *Section 5.2*.

7.2.12.2
KEYPAD REPLACEMENT

The recommended tools for this procedure are a #2 Phillips screwdriver, medium size flat blade screwdriver, and an X-acto knife.

The replacement parts for this procedure are:

Assembly, Keypad
Gasket, Ground
Assembly, Cable, Keypad/CPU
Spacer
Screw, 4-24 x 1/4, Pan Head, Phillips
Screw, 4-40 x 3/16, Hex Head, Slotted, with Washer

To replace the keypad, see *Figure 7-12*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Disconnect the keypad cable from the CPU PWA.
5. Using the X-acto knife, lift the white insulation tape that secures the grounding tab to the lower main chassis.
6. Using the Phillips screwdriver, remove the screw that secures the keypad and display assembly to the main chassis *(see Figure 7-14)*.
7. Carefully disconnect the flex ribbon cable from the display assembly by pushing the connector locking tabs down.
8. Using the flat blade screwdriver, separate the keypad and display by removing the screws and spacers that secure the keypad to the display assembly.
9. Inspect the keypad ground gasket and replace, if required.

   Note: The keypad ground gasket will not be present on earlier versions of the Plum A+®.

10. Install the replacement keypad in the exact reverse order of removal.
11. Install the keypad and display assembly in the exact reverse order of removal.
12. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
13. Reinstall the battery and connect the device to AC power.

To verify successful keypad and ground gasket replacement, perform the PVT in *Section 5.2*.

7.2.12.3
DISPLAY REPLACEMENT

The recommended tools for this procedure are a #2 Phillips screwdriver and a medium size flat blade screwdriver.

The replacement parts for this procedure are:

Assembly, Display
Screw, 4-40 x 3/16, Hex Head, Slotted, with Washer

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the display assembly, see *Figure 7-12*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Remove the keypad as described in *Section 7.2.12.2*, then remove the display.
5. Install the replacement display assembly in the exact reverse order of removal.

6. Reassemble the keypad and display assembly.
7. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
8. Reinstall the battery and connect the device to AC power.

To verify successful display replacement, perform the PVT in *Section 5.2*.

7.2.12.4
CPU PWA REPLACEMENT

The recommended tool for this procedure is a medium size flat-blade screwdriver.

The replacement parts for this procedure are:

PWA, CPU
Insulator, CPU
Screw, 4-40 x 1/4, Hex Head, Slotted, with Washer

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the CPU PWA, see *Figure 7-12* and *Figure 7-13*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Remove the power supply PWA as described in *Section 7.2.12.1*.
5. Remove the display assembly as described in *Section 7.2.12.3*.
6. Using the flat blade screwdriver, remove the two screws that secure the CPU PWA and CPU insulator to the main chassis.
7. Inspect and replace the CPU insulator, if required.
8. Install the replacement CPU PWA in the exact reverse order of removal.
9. Reassemble the keypad, display assembly, CPU PWA, and power supply PWA.
10. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
11. Reinstall the battery and connect the infuser to AC power.

To verify successful CPU PWA replacement, perform the PVT in *Section 5.2*.

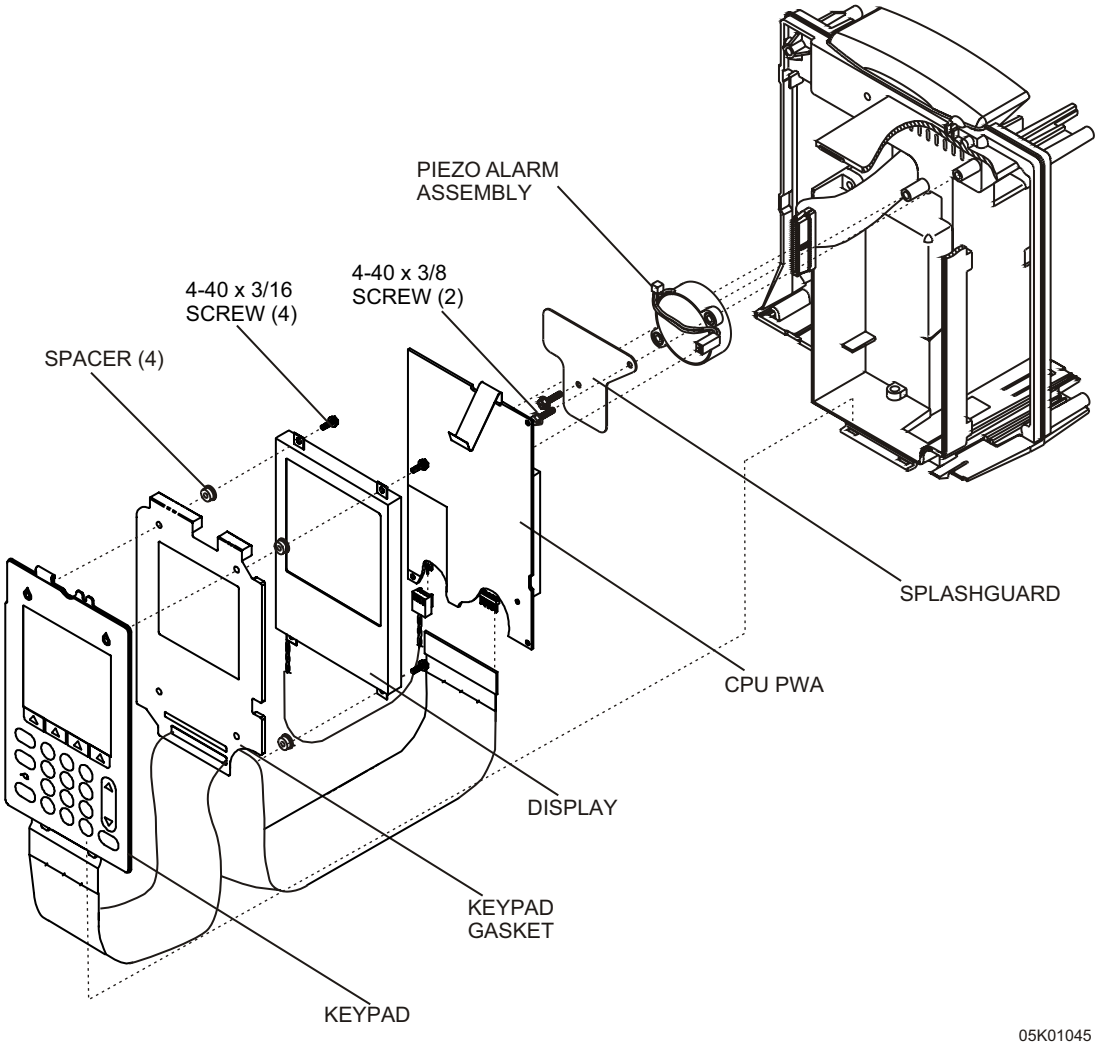

Figure 7-12. Keypad, Display, CPU PWA, and Piezo Alarm

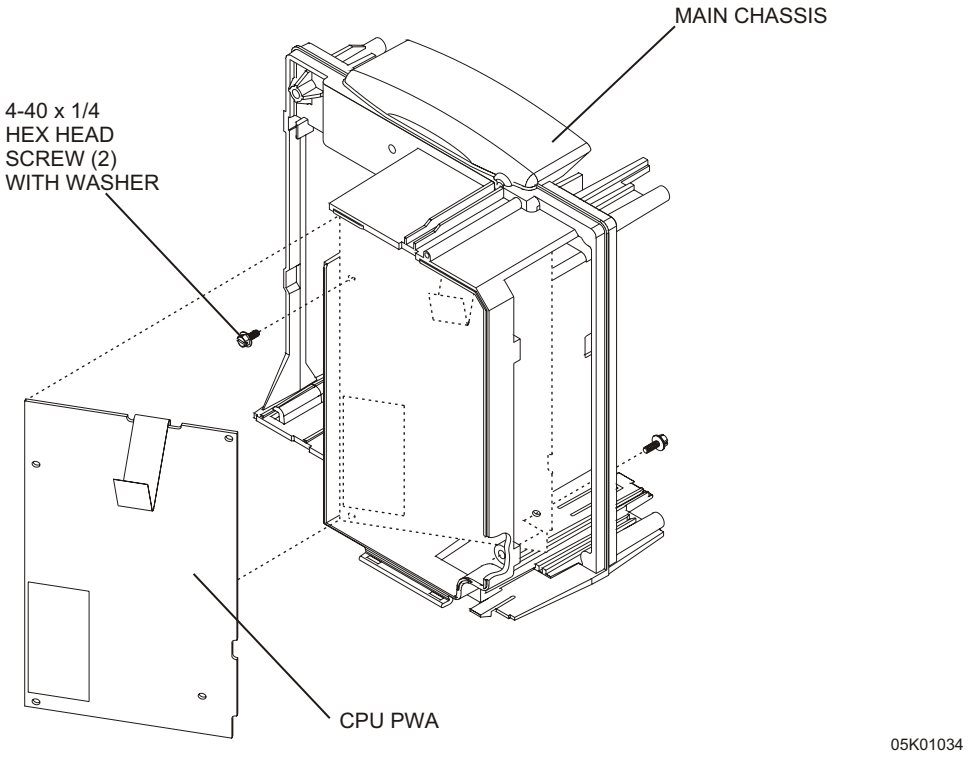

Figure 7-13. CPU PWA Replacement

7.2.12.5

PIEZO ALARM REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

The replacement parts for this procedure are:

Assembly, Piezo Alarm
Splashguard
Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the piezo alarm assembly, see *Figure 7-12*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Remove the power supply PWA as described in *Section 7.2.12.1*.
5. Remove the CPU assembly as described in *Section 7.2.12.4*.
6. Using the flat blade screwdriver, remove the screws that secure the splashguard and piezo alarm to the main chassis.

Note: Note the alignment of the piezo alarm assembly connecting wires, and verify the replacement assembly is aligned the same way.

7. Install the replacement piezo alarm assembly in the exact reverse order of removal.
8. Reassemble the keypad, display assembly, CPU PWA, and power supply PWA.
9. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
10. Reinstall the battery and connect the device to AC power.

To verify successful piezo alarm replacement, perform the PVT in *Section 5.2*.

7.2.12.6
MECHANISM ASSEMBLY REPLACEMENT

The recommended tools for this procedure are a medium size flat blade screwdriver, #2 Phillips screwdriver, and diagonal cutters.

The replacement parts for this procedure are:

Assembly, Mechanism
Assembly, Cable, CPU/Driver
Bumper, Mechanism Chassis
Tie, Cable
Screw, 4-24 x 1/4, Pan Head, Phillips
Screw, 6-32 x 3/8, Hex Head, Slotted, with Washer

Note: Replacing the mechanism changes the biomed settings to those stored in the mechanism.

To replace the mechanism assembly, see *Figure 7-14*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Using diagonal cutters, cut the cable tie that secures the power supply/driver cable.
5. Using the flat blade screwdriver, remove the screw that secures the mechanism assembly to the main chassis assembly.
6. Inspect the mechanism chassis bumpers and replace, if required.
7. Slide the mechanism assembly away from the main chassis assembly.
8. Unlock and disconnect the CPU/driver cable from the mechanism assembly, and remove the mechanism assembly.
9. Install the replacement mechanism assembly in the exact reverse order of removal, and replace the cable tie.
10. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
11. Reinstall the battery and connect the device to AC power.

To verify successful mechanism assembly replacement, perform the PVT in *Section 5.2*.

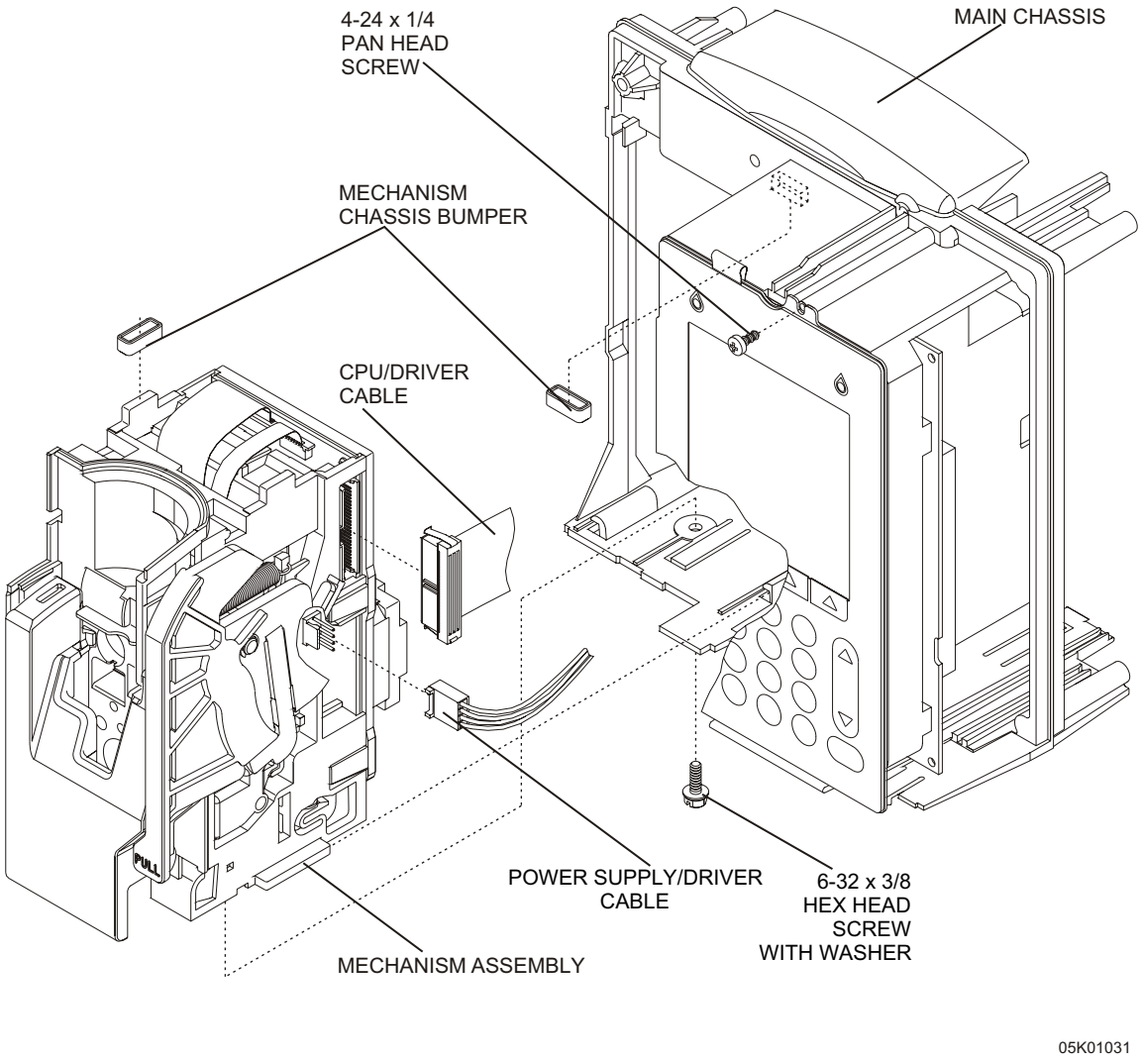

Figure 7-14. Mechanism Assembly Replacement

7.2.12.7
CASSETTE DOOR AND FLUID SHIELD REPLACEMENT

Recommended tools for this procedure are a medium size flat-blade screwdriver and long needle nose pliers.

The replacement parts for this procedure are:

Assembly, Cassette Door
Assembly, Fluid Shield
Cap, Door Pivot
Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer

To replace the cassette door and fluid shield, see *Figure 7-15* and *Figure 7-16*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Remove the mechanism assembly as described in *Section 7.2.12.6*.
5. Using the flat blade screwdriver, remove the screw that secures the door pivot cap to the mechanism assembly. Disengage the cassette door from the opener handle assembly and remove the door.
6. Disengage the clips on the back side of the fluid shield that secure the upper portion of the shield to the mechanism assembly.
7. Lift the locking pins to release the fluid shield/driver flex connector, and disconnect the flex connector from the driver PWA.
8. Pull the shield away from the top of the mechanism assembly at an approximate 15-degree angle. Pull the shield up and away, clearing the mechanism assembly pins and plunger.

   Note: Prior to fluid shield replacement, align the mechanism assembly pins.

9. Install the replacement fluid shield in the exact reverse order of removal.
10. Install the replacement cassette door in the exact reverse order of removal.
11. Replace the mechanism assembly in the exact reverse order of removal.
12. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
13. Reinstall the battery and connect the device to AC power.

To verify successful cassette door and fluid shield replacement, perform the PVT in *Section 5.2*.

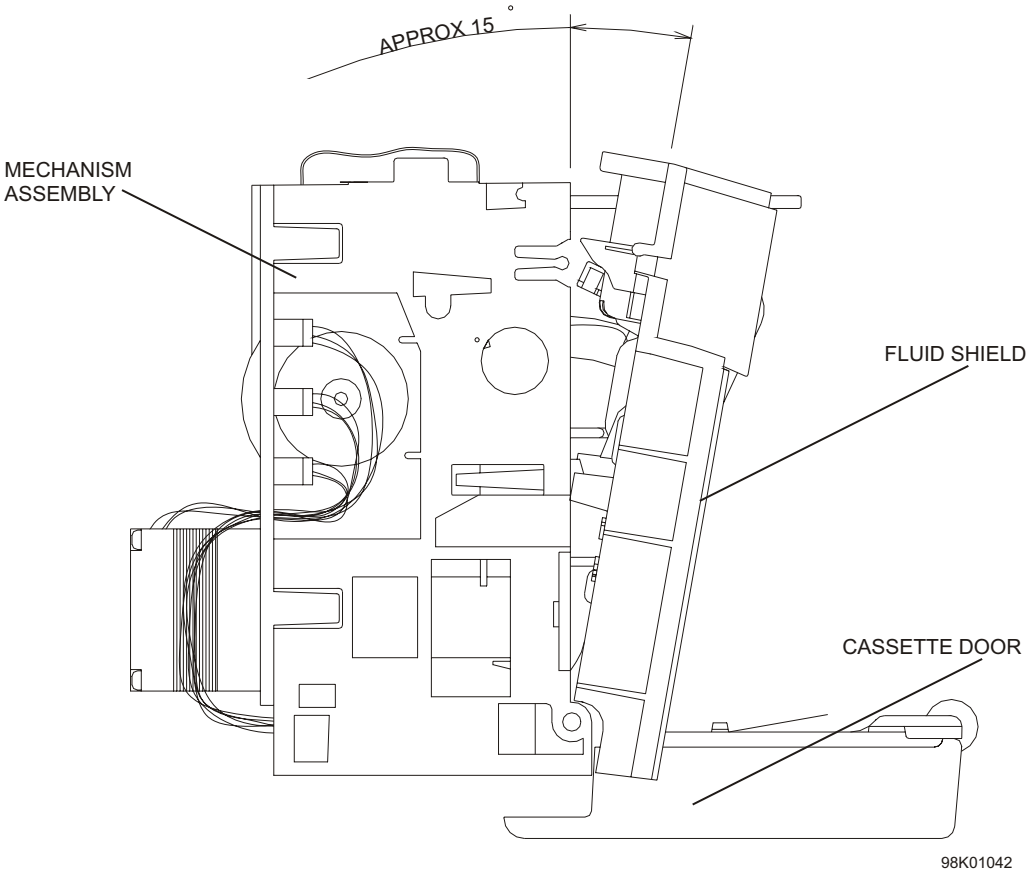

Figure 7-15. Fluid Shield Replacement

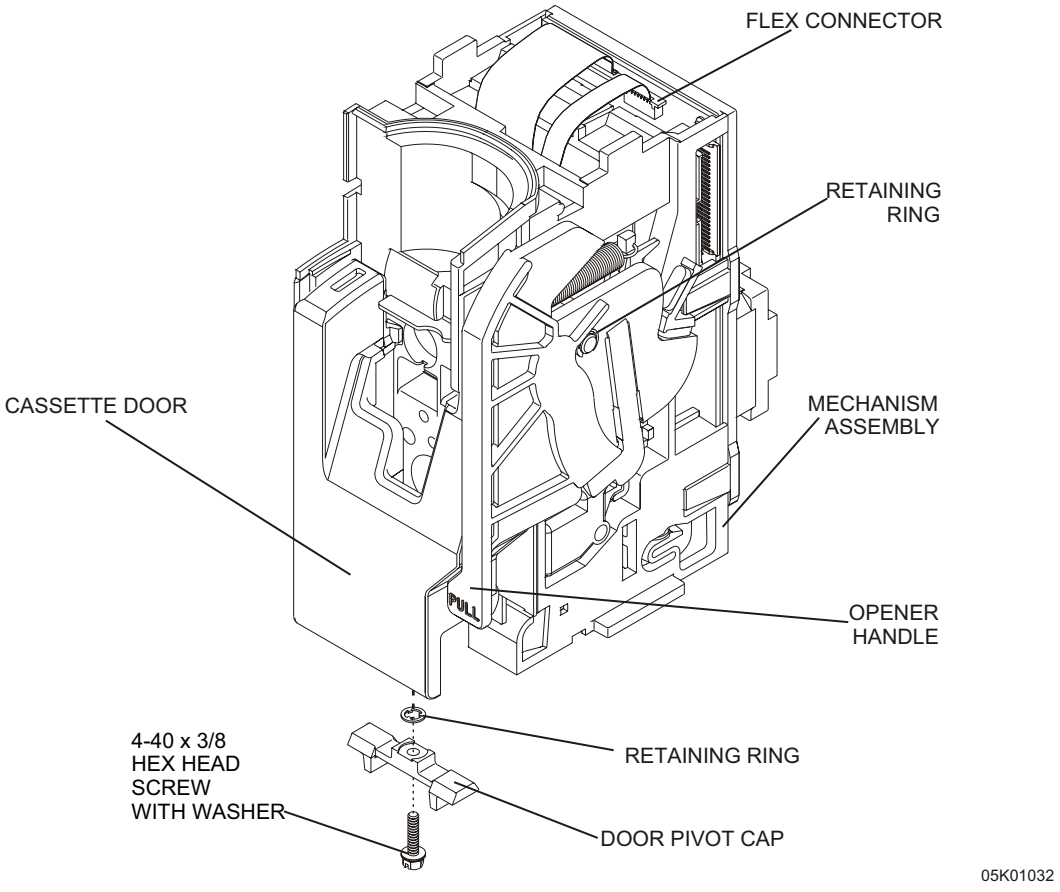

Figure 7-16. Cassette Door and Opener Handle Replacement

7.2.12.8

OPENER HANDLE ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

The replacement parts for this procedure are:

Assembly, Opener Handle
Ring, Retaining, Push-On, 3/32

To replace the opener handle assembly, see *Figure 7-16*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Remove the battery as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.8*.
4. Remove the mechanism assembly as described in *Section 7.2.12.6*.
5. Open the cassette door. Disengage and fully open the cassette door from the opener handle assembly. Close the opener handle assembly.
6. Remove the retaining ring, and replace, if required.
7. Insert the flat blade screwdriver between the opener handle assembly and the mechanism assembly, and carefully pry the assemblies apart.
8. Install the replacement opener handle assembly in the exact reverse order of removal. Confirm the opener handle is aligned properly.
9. Replace the mechanism assembly in the exact reverse order of removal.
10. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
11. Reinstall the battery and connect the device to AC power.

To verify successful opener handle assembly replacement, perform the PVT in *Section 5.2*.

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Section 8

SPECIFICATIONS

The following specifications apply to the Plum A+® infusion system.

PHYSICAL

Dimensions: Approximately 8 H x 8 W x 6 D inches (excluding pole clamp and power cord storage)

Weight: Approximately 9.5 lbs (with battery)

Casing: High-impact plastic

ELECTRICAL

Power Requirements: 120 V_{AC}; 50-60 Hz; 35 W

Power Cord: Hospital-grade AC cord; 10 feet; with transparent plug and retainer

Fuses: 0.5 A; 250 V_{AC}

Battery: Sealed lead acid; rechargeable; 6 V; internal

Battery Operation: A fully charged new battery provides approximately six hours of operation at 125 mL/hr, or delivers 500 mL.

Operation time is measured from initial pumping to the Depleted Battery alarm.

The infuser should be operated on battery power for three continuous hours every six months for optimum performance and battery life.

Recharge: The battery charges whenever the infuser is connected to AC power.

If the infuser is operating at 125 mL/hr on one line, a full recharge takes approximately six hours.

Self-Discharge: 50 % of charge is retained for a minimum of one month when the infuser is not connected to AC power or is not operating.

Nurse Call System: Circuitry Ratings: Voltage - 30 V_{DC} Max
Current - 0.25 A max
Contact Rating - 3 W max

Default: Normally-open (NO)

Contact Hospira Technical Support Operations to make an internal adjustment to change the device from normally-open to normally-closed (NC).

ENVIRONMENT

Operating: 41° to 104° F; 10 % to 90 % relative humidity

Transporting and Storage: -4° to 140° F; 10 % to 90 % relative humidity

Atmospheric Pressure: 0 - 10,000 feet or equivalent pressure

Relative Humidity: 10 - 90 % (104° F max)

DELIVERY RATE RANGE

Lines A and B: 0.1 to 99.9 mL/hr (in 0.1 mL/hr increments)
100 to 999 mL/hr (in 1 mL/hr increments)

Concurrent Delivery: 0.5 mL/hr minimum for each line

PlumSet: 500 mL/hr cumulative (A+B) maximum

KVO: 1 mL/hr or the last primary delivery rate, whichever is less

VTBI Range: 0.1 to 99.9 mL (in 0.1 mL/hr increments)
100 to 9999 mL (in 1 mL/hr increments)

OCCLUSION ALARM AND LIMITS

Distal: The Distal Occlusion alarm sounds after the distal tubing or set outlet fitting becomes occluded.

Proximal: The Proximal Occlusion alarm sounds if the tubing proximal to the cassette becomes occluded.

Distal Pressure Limit (without alarm): 1 to 15 psi;
Maximum pressure limit is user-selectable;
Factory setting is 6 psi.

Maximum Infusion Pressure: 20 psi

AIR-IN-LINE ALARM

PlumSet (Distal): Bolus: 0.5 mL of air or larger
Cumulative: 0.5 mL of air out of 5.3 mL of fluid

PlumSet (Proximal): Bolus at 0.5 mL, total 1 mL (0.5 mL concurrent)

Section 9
DRAWINGS

Figure 9-1 through *Figure 9-15* show the illustrated parts breakdown (IPB), infuser assembly diagrams, and PWA schematic diagrams. *Table 9-1* lists drawings by figure number, title, and part number. *Table 9-2* identifies parts by index numbers which correlate to *Figure 9-1*.

Note: Drawings and schematics in *Section 9* are provided as information only. Drawings and schematics may not exactly reflect current product configuration.

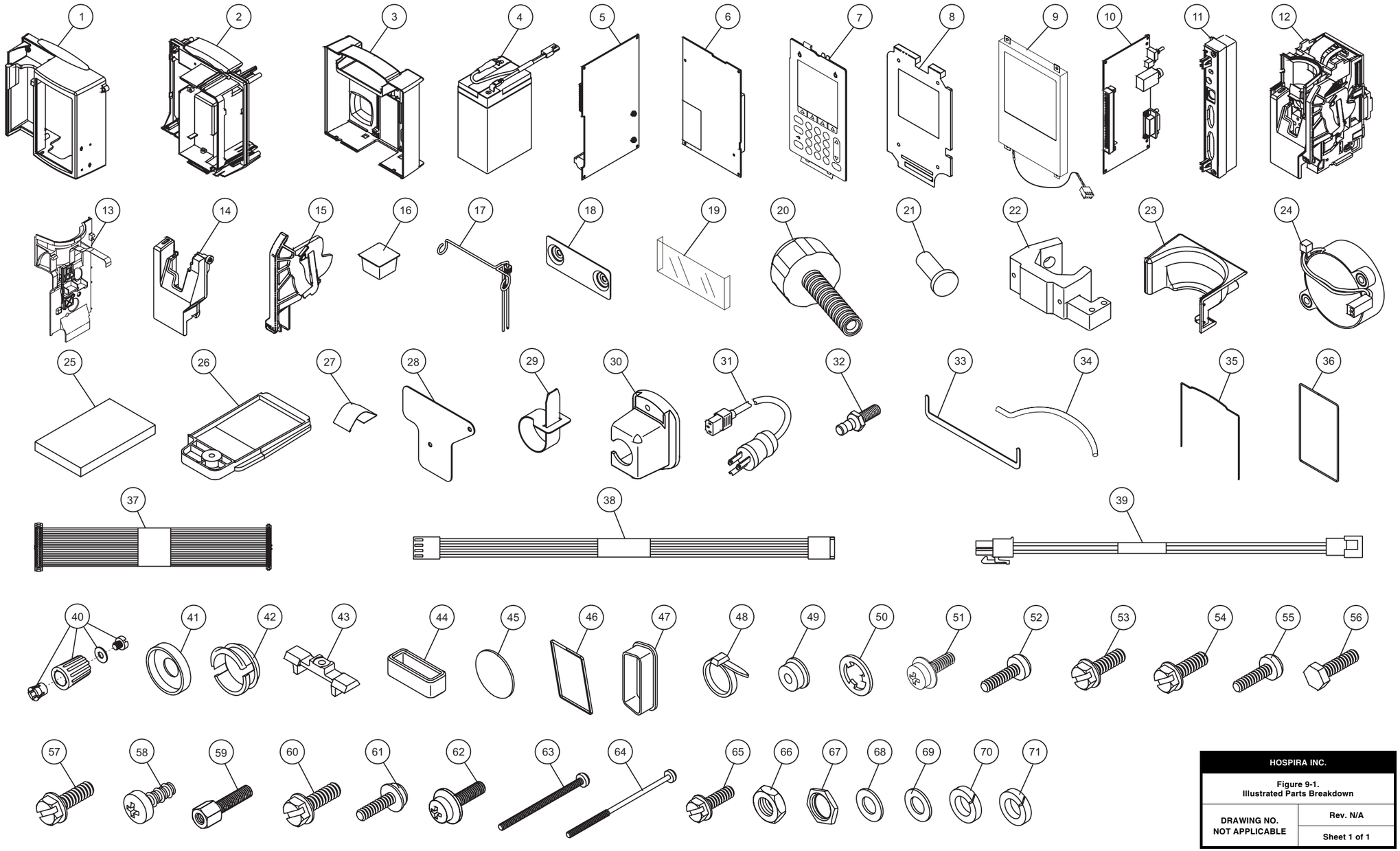
Table 9-1. Drawings

Figure Number	Title	Drawing Number
9-1	Illustrated Parts Breakdown	Not Applicable
9-2	Front Enclosure, Rear Enclosure, and Main Chassis	
9-3	Front Enclosure Assembly	
9-4	Rear Enclosure Assembly	
9-5	Peripheral Assembly	
9-6	Main Chassis Assembly (3 sheets)	
9-7	AC Power Cord, Retainer, and Battery Assembly	
9-8	CPU PWA and Main Chassis	
9-9	Mechanism Assembly	
9-10	Power Supply PWA Schematic (5 sheets)	249-95242
9-11	Peripheral PWA Schematic (4 sheets)	249-95006
9-12	CPU PWA Schematic (10 sheets)	249-95007
9-13	Driver PWA Schematic (6 sheets)	249-95018
9-14	Switch PWA Schematic	249-95022
9-15	APP PWA Schematic (3 sheets)	249-95034

Table 9-2. IPB for the Infuser		
Index Number	**Nomenclature**	**Replacement Procedure**
1	Enclosure, Front	*Section 7.2.9*
2	Chassis, Main	*Section 7.2.9*
3	Enclosure, Rear	*Section 7.2.9*
4	Assembly, Battery, with Wire Harness	*Section 7.2.4*
5	PWA, Power Supply	*Section 7.2.12.1*
6	PWA, CPU	*Section 7.2.12.4*
7	Keypad	*Section 7.2.12.2*
8	Gasket, Ground	*Section 7.2.12.2*
9	Assembly, Display	*Section 7.2.12.3*
10	PWA, Peripheral	*Section 7.2.6*
11	Cover, Peripheral	*Section 7.2.7.2*
12	Assembly, Mechanism	*Section 7.2.12.6*
13	Assembly, Fluid Shield	*Section 7.2.12.7*
14	Assembly, Cassette Door	*Section 7.2.12.7*
15	Assembly, Opener Handle	*Section 7.2.12.8*
16	Foot, Rubber	*Section 7.2.3*
17	Assembly, Minipole	*Section 7.2.11*
18	Plate, Backing, Pole Clamp	*Section 7.2.10.1*
19	Tape, Insulation	*Section 7.2.10.1*
20	Assembly, Shaft/Knob, Pole Clamp	*Section 7.2.10.2*
21	Tip, Shaft, Pole Clamp	*Section 7.2.10.2*
22	Extrusion, Pole Clamp	*Section 7.2.10.1*
23	Shoe, Front Enclosure	*Section 7.2.9*
24	Assembly, Piezo Alarm	*Section 7.2.12.5*
25	Pad, Door	*Section 7.2.4*
26	Door, Battery	*Section 7.2.4*
27	Gasket, Battery Door	*Section 7.2.4*
28	Splashguard	*Section 7.2.12.5*
29	Strap, Velcro	*Section 7.2.5*
30	Retainer, AC Power Cord	*Section 7.2.5*
31	Cordset, AC Power, Detachable	*Section 7.2.5*

Table 9-2. IPB for the Infuser		
Index Number	**Nomenclature**	**Replacement Procedure**
32	Terminal, Equipotential	*Section 7.2.5*
33	Gasket, Handle	*Section 7.2.10.3*
34	Gasket, Shoe	*Section 7.2.9.1*
35	Gasket, Rear Enclosure	*Section 7.2.10.3*
36	Gasket, Front/Rear Enclosure	*Section 7.2.9.2*
37	Cable, CPU/Driver	*Section 7.2.12.6*
38	Cable, Power Supply/Driver	*Section 7.2.12.1*
39	Cable, Power Supply/Battery	*Section 7.2.12.1*
40	Assembly, Volume Control Knob	*Section 7.2.7.1*
41	Cover, Nut	*Section 7.2.7.1*
42	Cap, Knob	*Section 7.2.7.1*
43	Cap, Door Pivot	*Section 7.2.12.7*
44	Bumper, Mechanism	*Section 7.2.12.6*
45	Seal, Round	*Section 7.2.7.2*
46	Seal, Rectangle	*Section 7.2.7.2*
47	Cover, DataPort Connector	*Section 7.2.7.2*
48	Tie, Cable	*Section 7.2.12.6*
49	Spacer	*Section 7.2.12.2*
50	Ring, Retaining	*Section 7.2.12.8*
51	Screw, 4-24 x 1/4, Pan Head, Phillips	As applicable
52	Screw, 4-40 x 1/4, Pan Head, Phillips	As applicable
53	Screw, 4-40 x 1/4, Hex Head, Slotted, with Washer	As applicable
54	Screw, 4-40 x 3/16, Hex Head, Slotted, with Washer	As applicable
55	Screw, 4-40 x 3/8, Pan Head, Phillips, with Washer	As applicable
56	Screw, 4-40 x 3/8, Hex Head, Nylon	*Section 7.2.7.2*
57	Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer	As applicable
58	Screw, 4-40 x 1/2, Pan Head, Square Cone, Phillips	As applicable
59	Screw, Jack, 4-40 x 7/16	*Section 7.2.5*
60	Screw, 6-32 x 3/8, Hex Head, Slotted, with Washer	As applicable
61	Screw, 6-32 x 1/2, Pan Head, Phillips	As applicable
62	Screw, 6-32 x 5/8, Pan Head, Phillips, with Washer	As applicable

Table 9-2. IPB for the Infuser		
Index Number	**Nomenclature**	**Replacement Procedure**
63	Screw, 6-32 x 2 1/2, Pan Head, Phillips	As applicable
64	Screw, 6-32 x 3 1/4, Pan Head, Phillips	As applicable
65	Screw, 10-32 x 1/2, Hex Head, Slotted, with Washer	As applicable
66	Nut, Hex, 4-40	As applicable
67	Nut, Hex, Nurse Call Jack	*Section 7.2.7.2*
68	Washer, Flat, #4	As applicable
69	Washer, Flat, Nylon	*Section 7.2.7.2*
70	Washer, Lock, Split, #4	As applicable
71	Washer, Lock, Helical, #6	As applicable



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HOSPIRA INC.	
Figure 9-1. Illustrated Parts Breakdown	
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	Sheet 1 of 1

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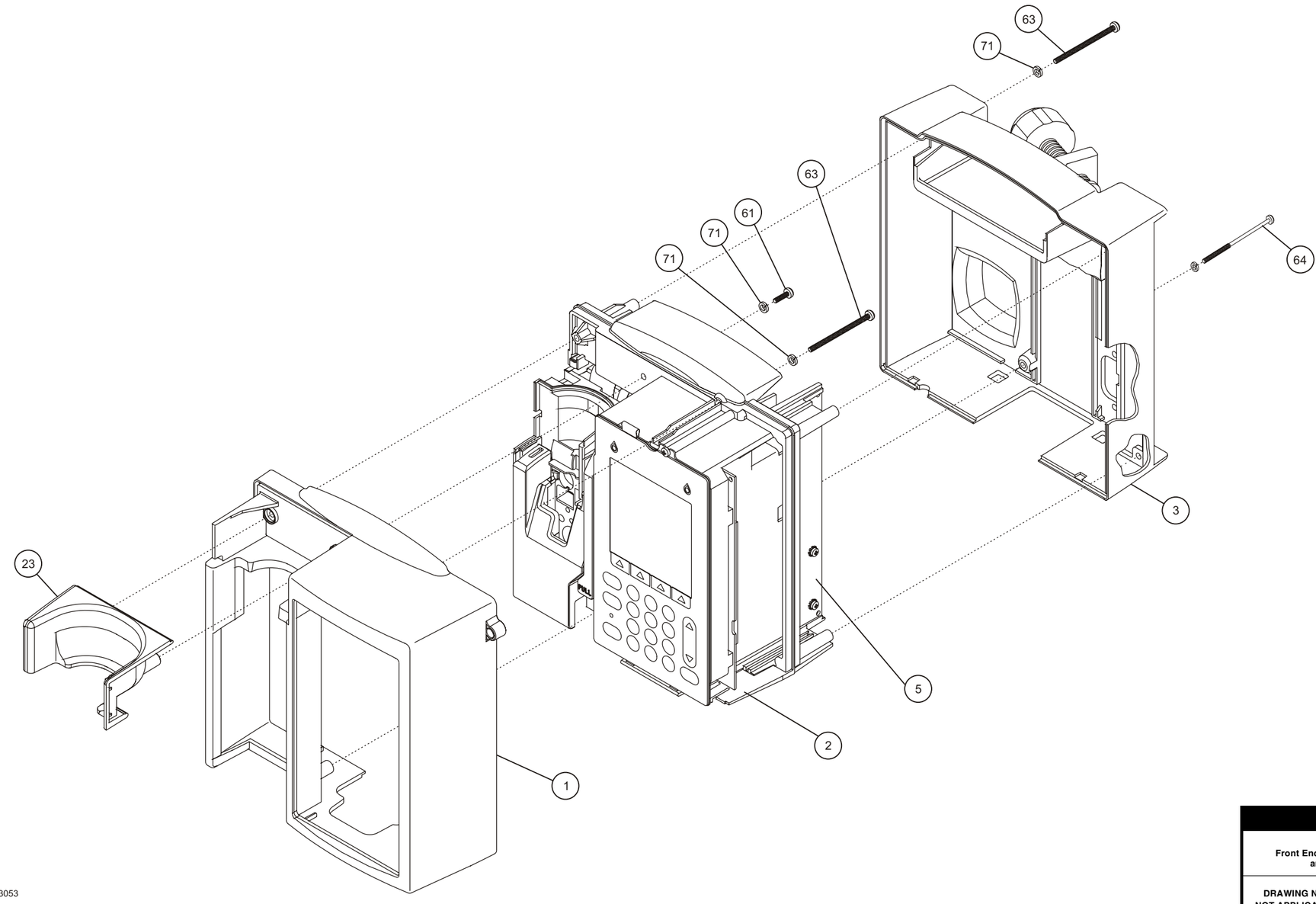

HOSPIRA INC.	
Figure 9-2. Front Enclosure, Rear Enclosure, and Main Chassis	
DRAWING NO. NOT APPLICABLE	Rev. N/A
	Sheet 1 of 1

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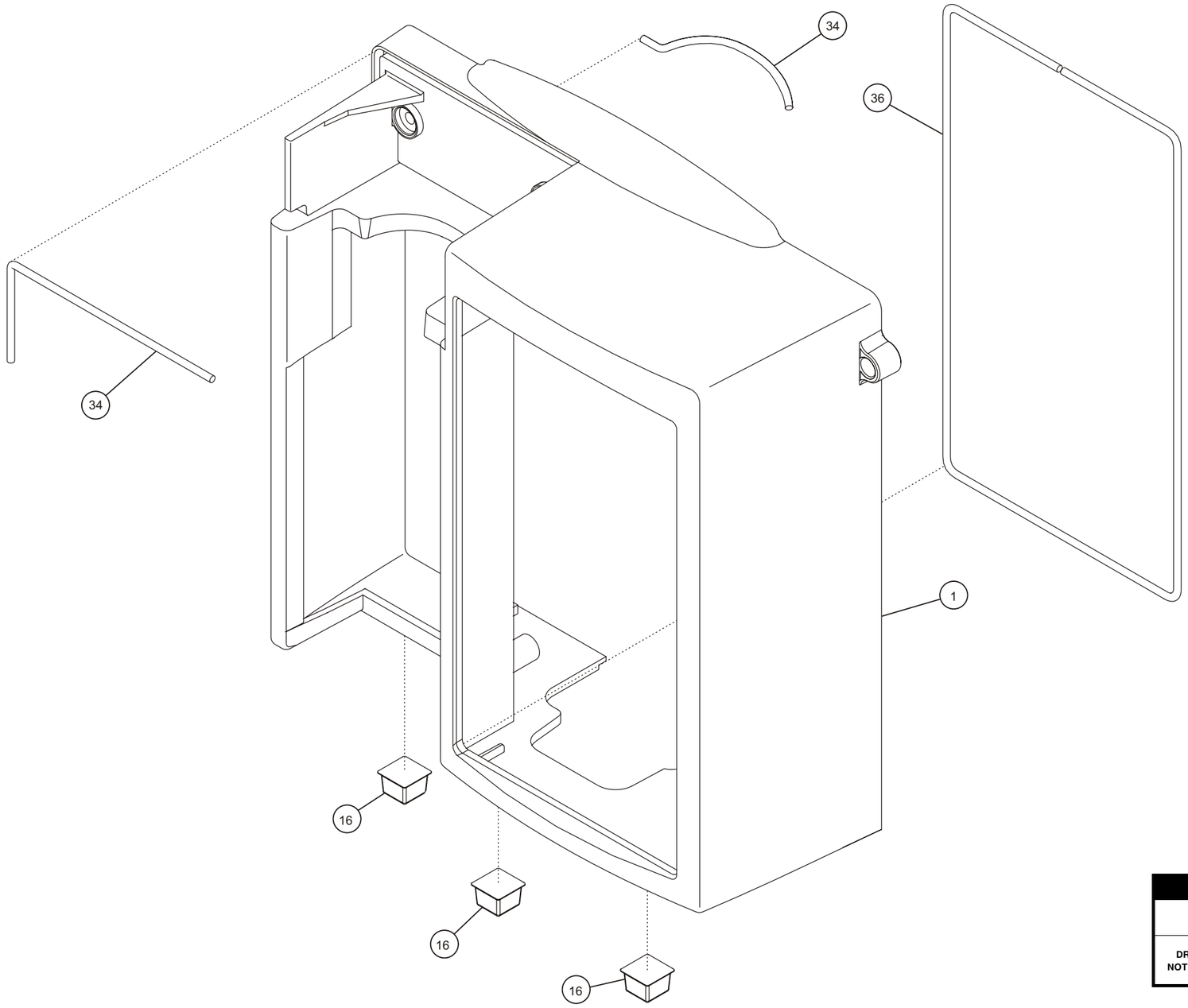

HOSPIRA INC.	
Figure 9-3. Front Enclosure Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A
	Sheet 1 of 1

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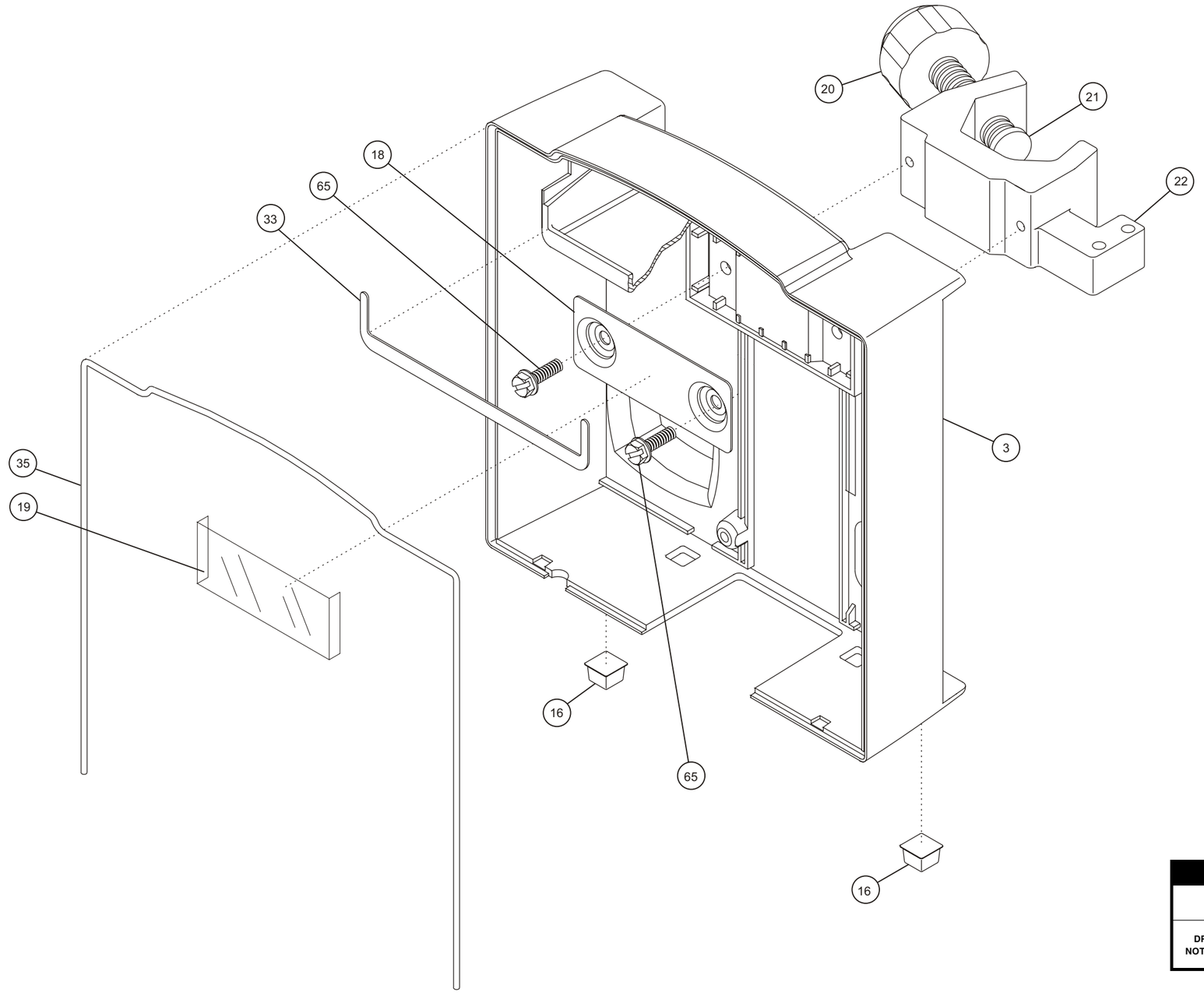

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HOSPIRA INC.	
Figure 9-4. Rear Enclosure Assembly	
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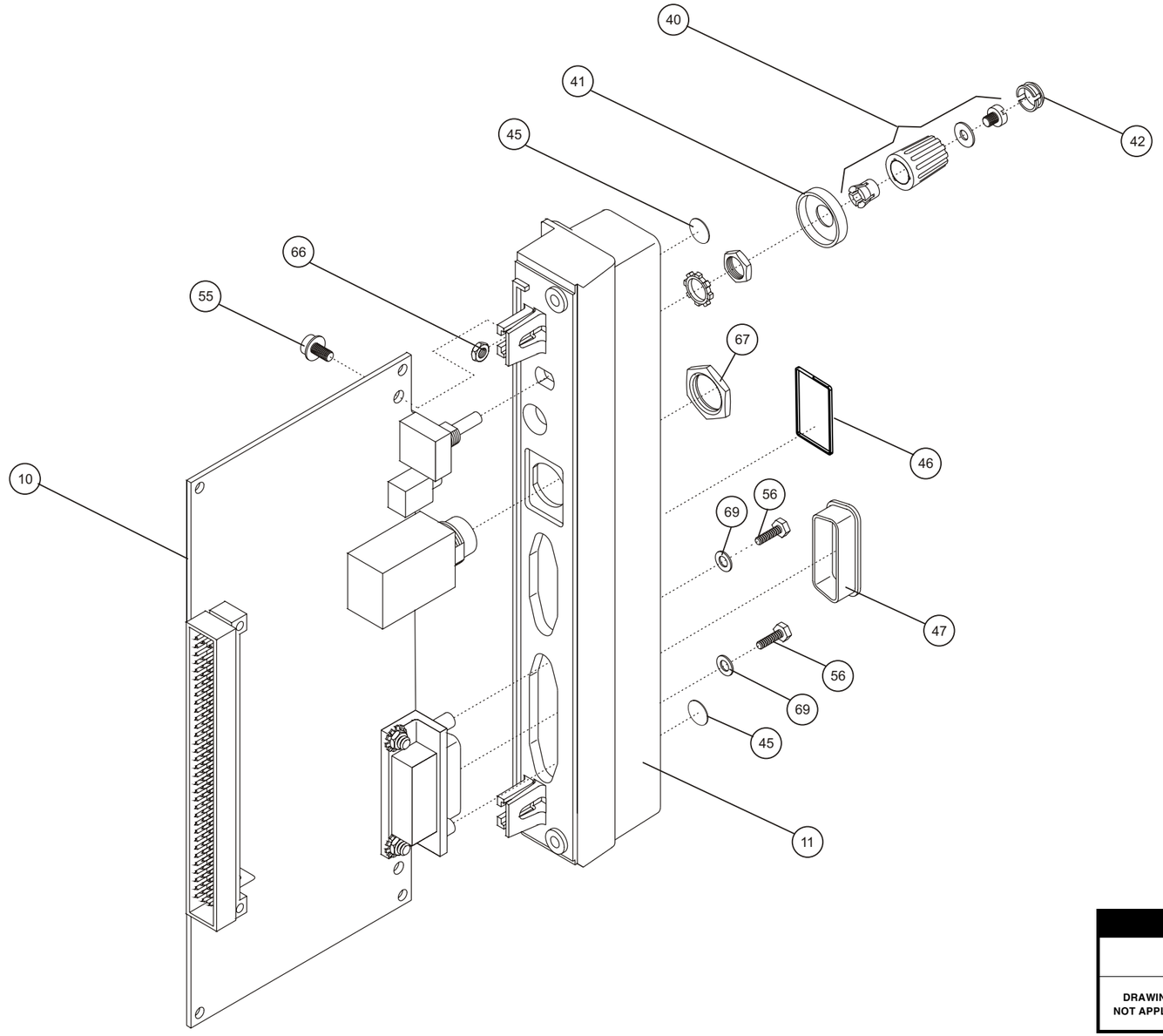

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HOSPIRA INC.	
Figure 9-5. Peripheral Assembly	
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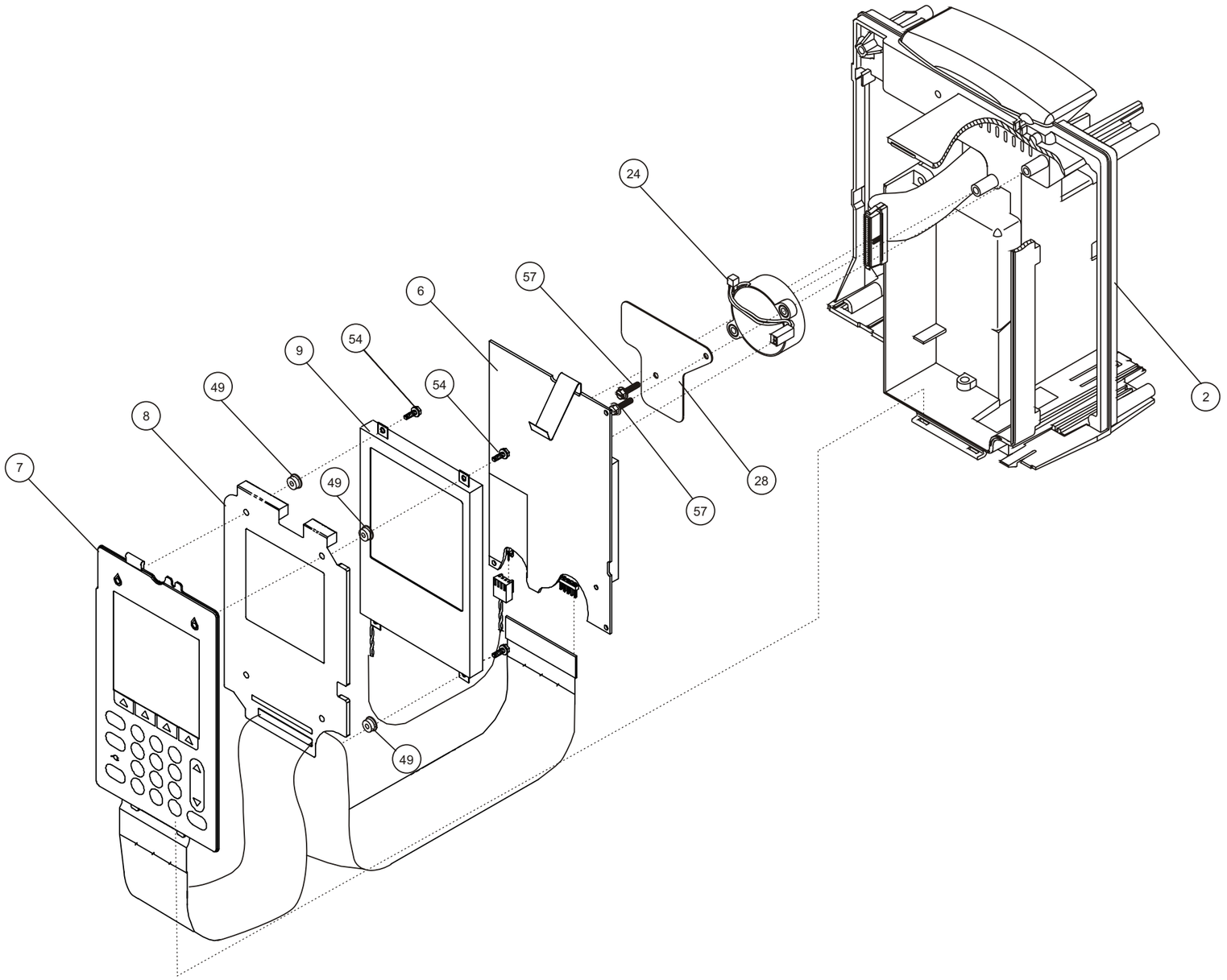

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HOSPIRA INC.	
Figure 9-6. Main Chassis Assembly	
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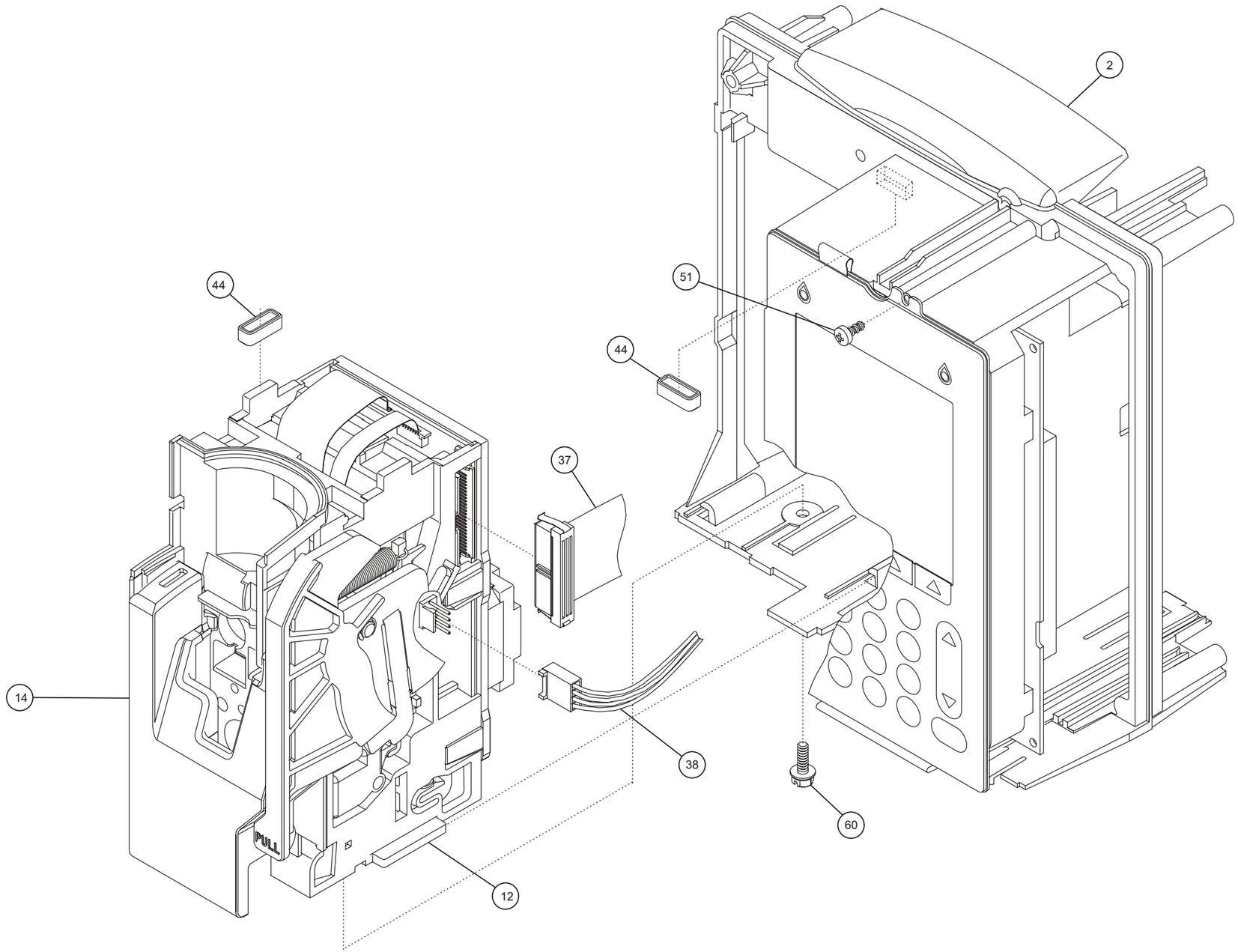

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HOSPIRA INC.	
Figure 9-6. Main Chassis Assembly	
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	Sheet 2 of 3

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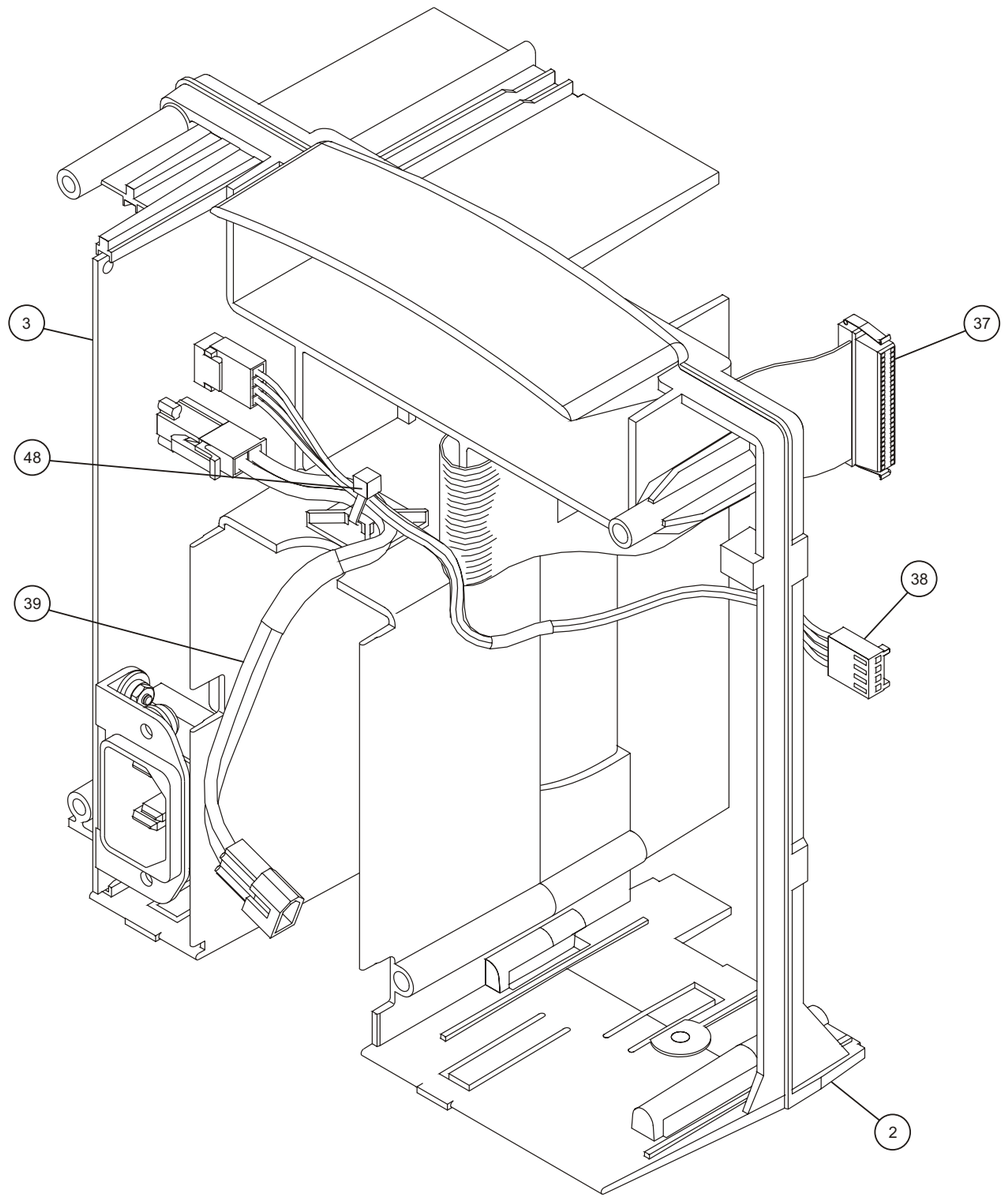

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HOSPIRA INC.	
Figure 9-6. Main Chassis Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A
	Sheet 3 of 3

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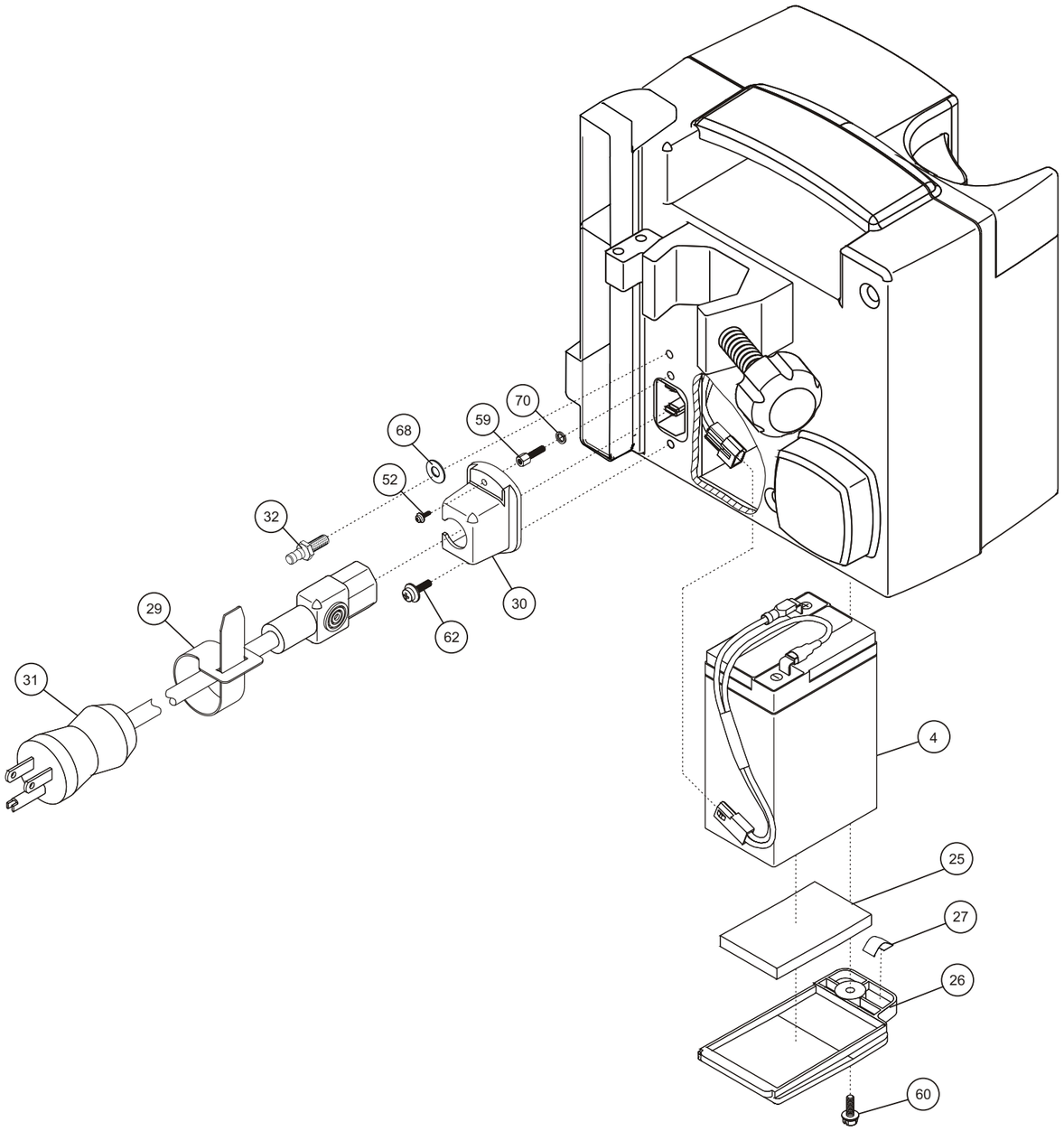

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HOSPIRA INC.	
Figure 9-7. AC Power Cord, Retainer, and Battery Assembly	
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	Sheet 1 of 1

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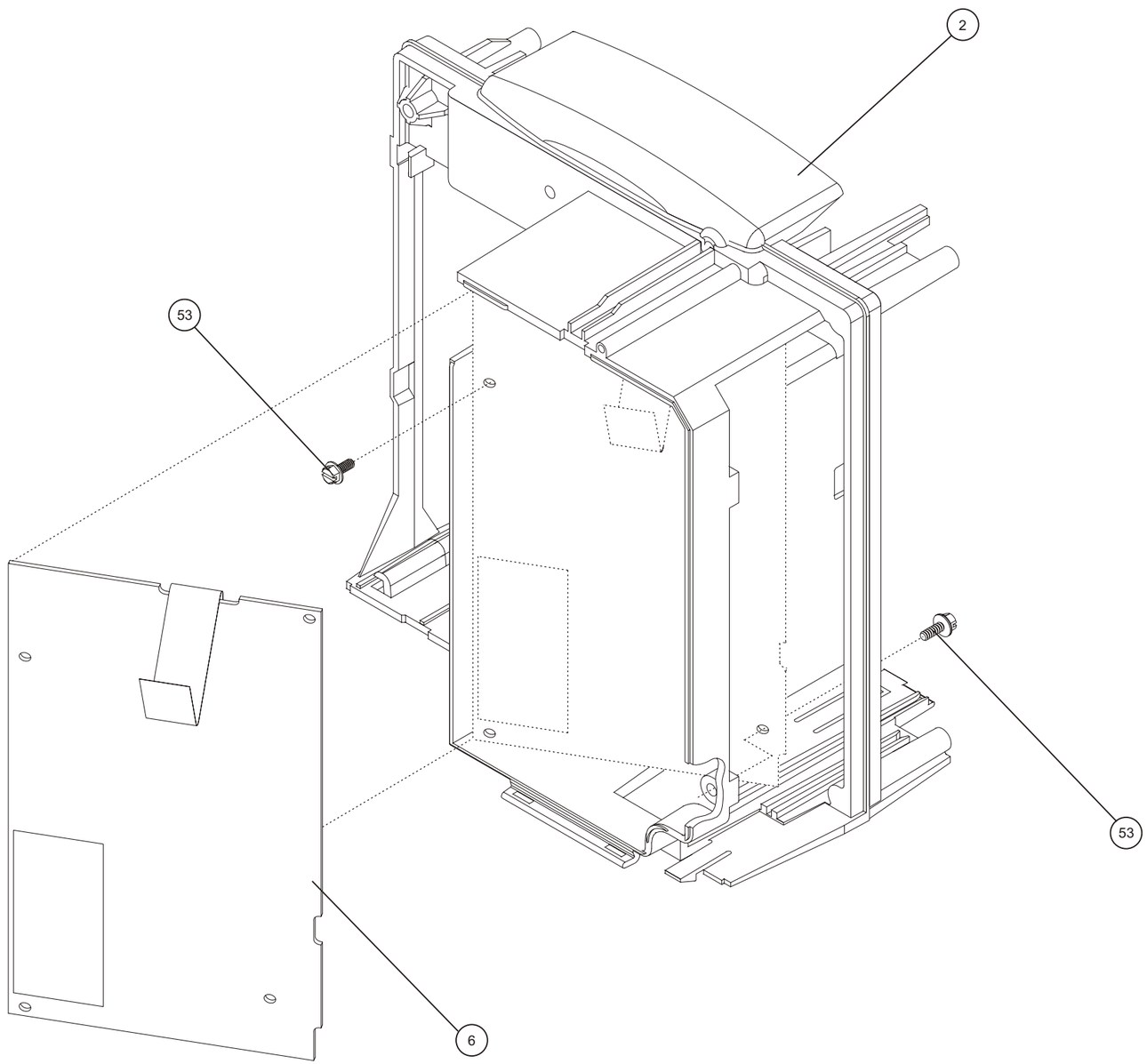

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HOSPIRA INC.	
Figure 9-8. CPU PWA and Main Chassis	
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	Sheet 1 of 1

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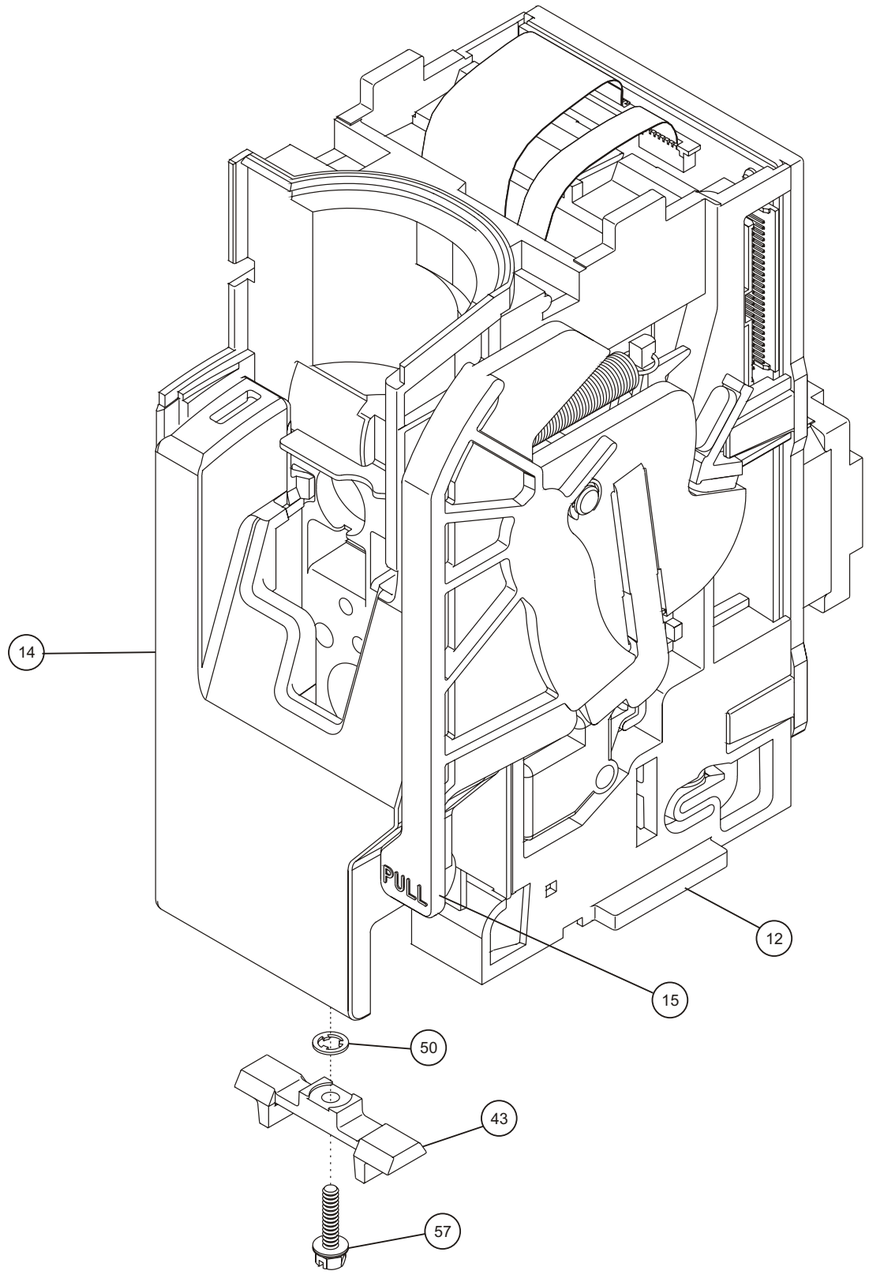

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HOSPIRA INC.	
Figure 9-9. Mechanism Assembly	
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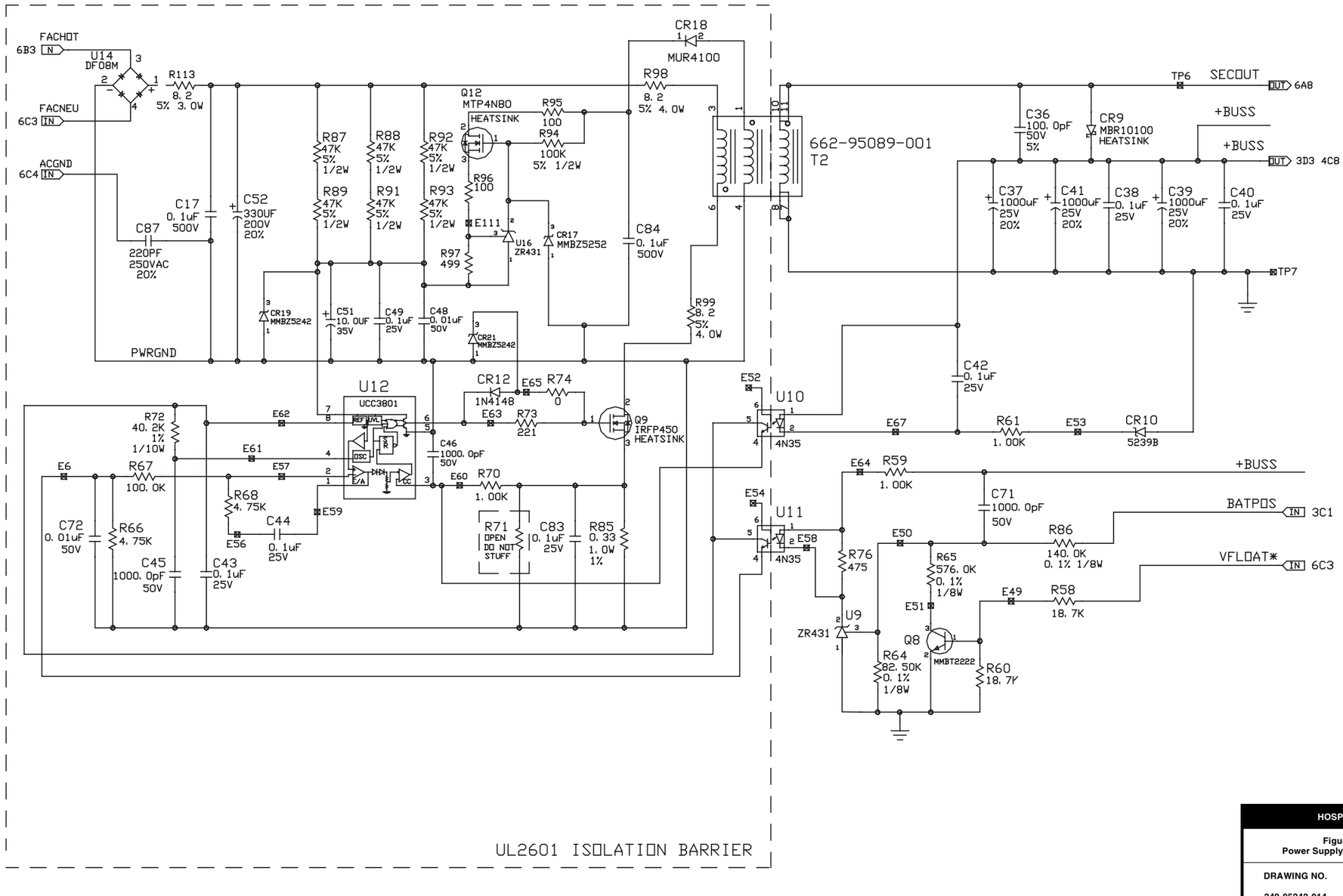

HOSPIRA INC.	
Figure 9-10. Power Supply PWA Schematic	
DRAWING NO. 249-95242-014	Rev. A Sheet 1 of 5

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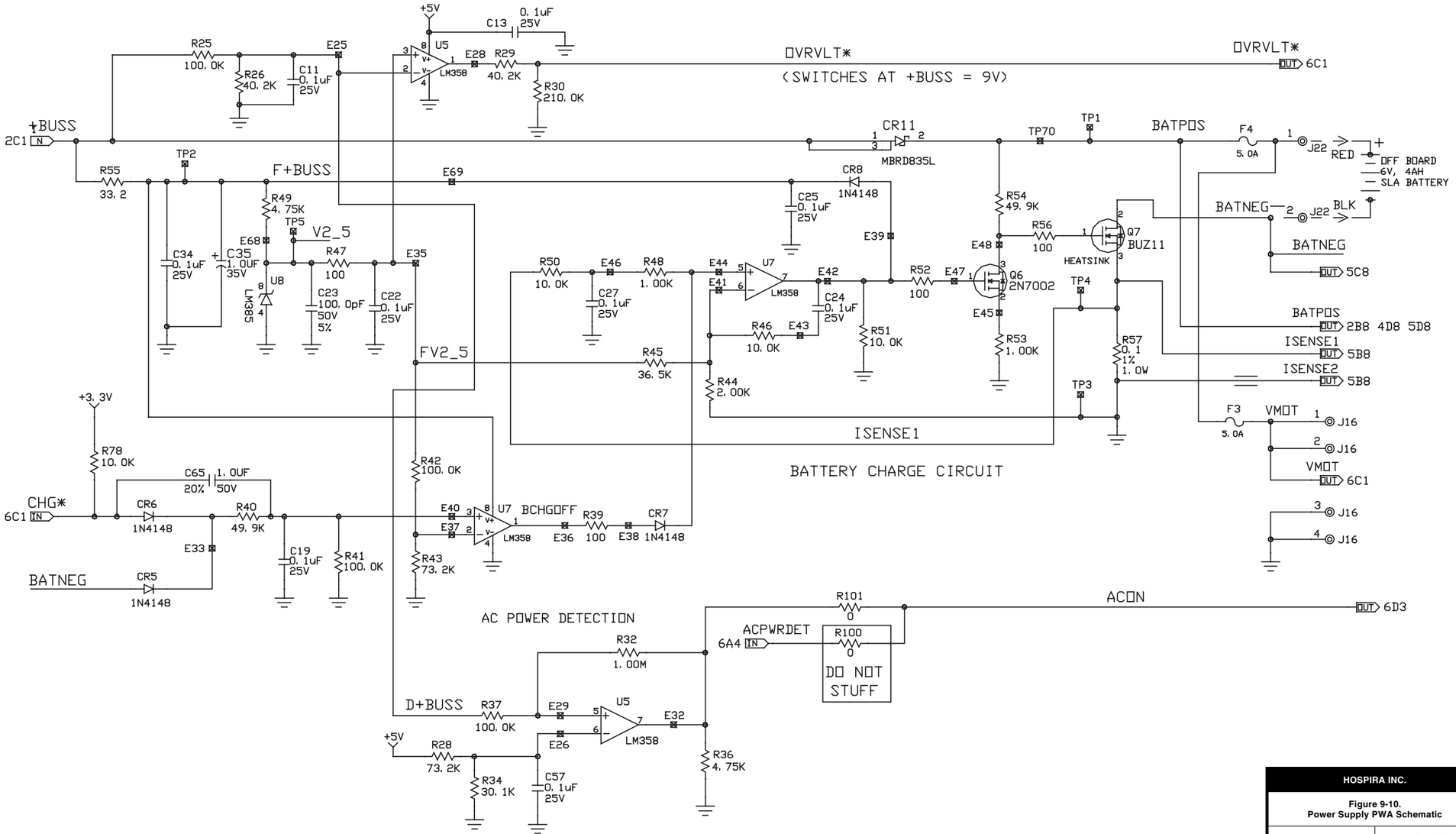

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Figure 9-10. Power Supply PWA Schematic	
DRAWING NO. 249-95242-014	Rev. A Sheet 2 of 5

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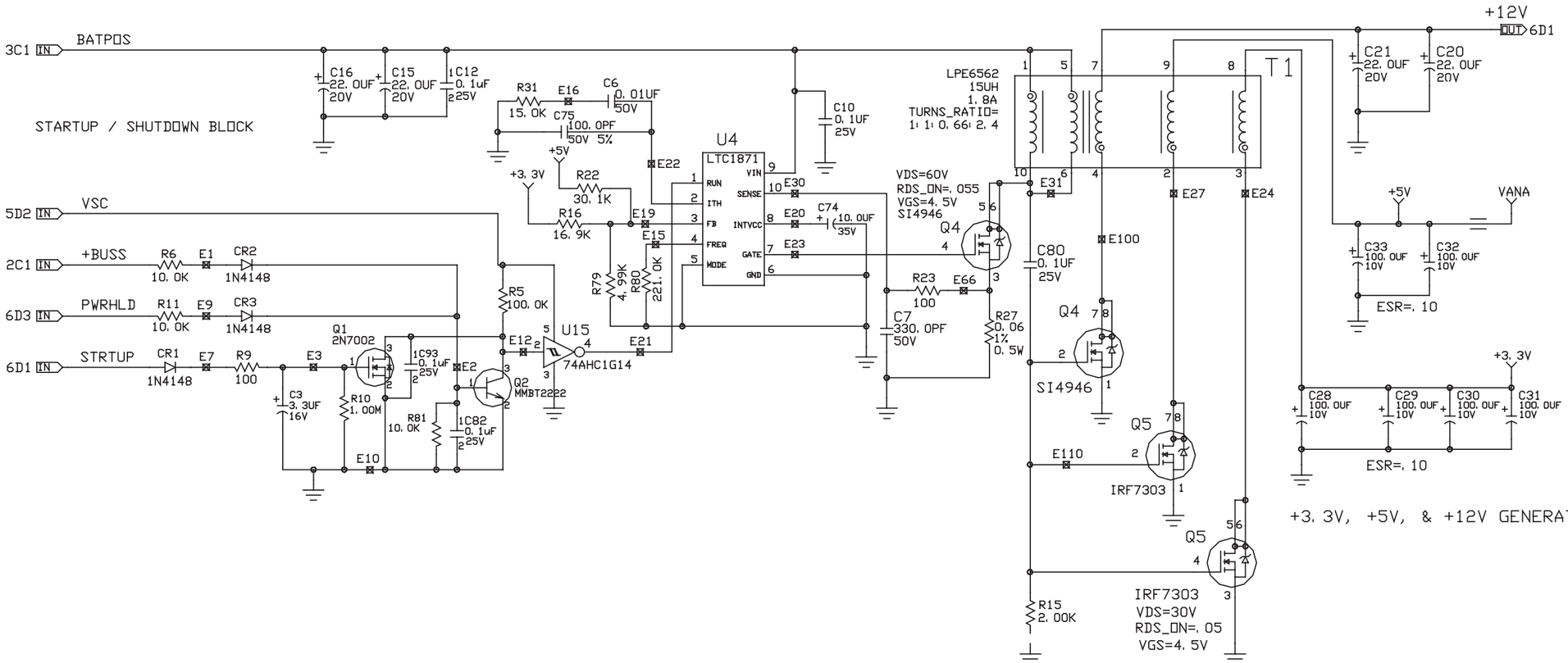

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Figure 9-10. Power Supply PWA Schematic	
DRAWING NO. 249-95242-014	Rev. A Sheet 3 of 5

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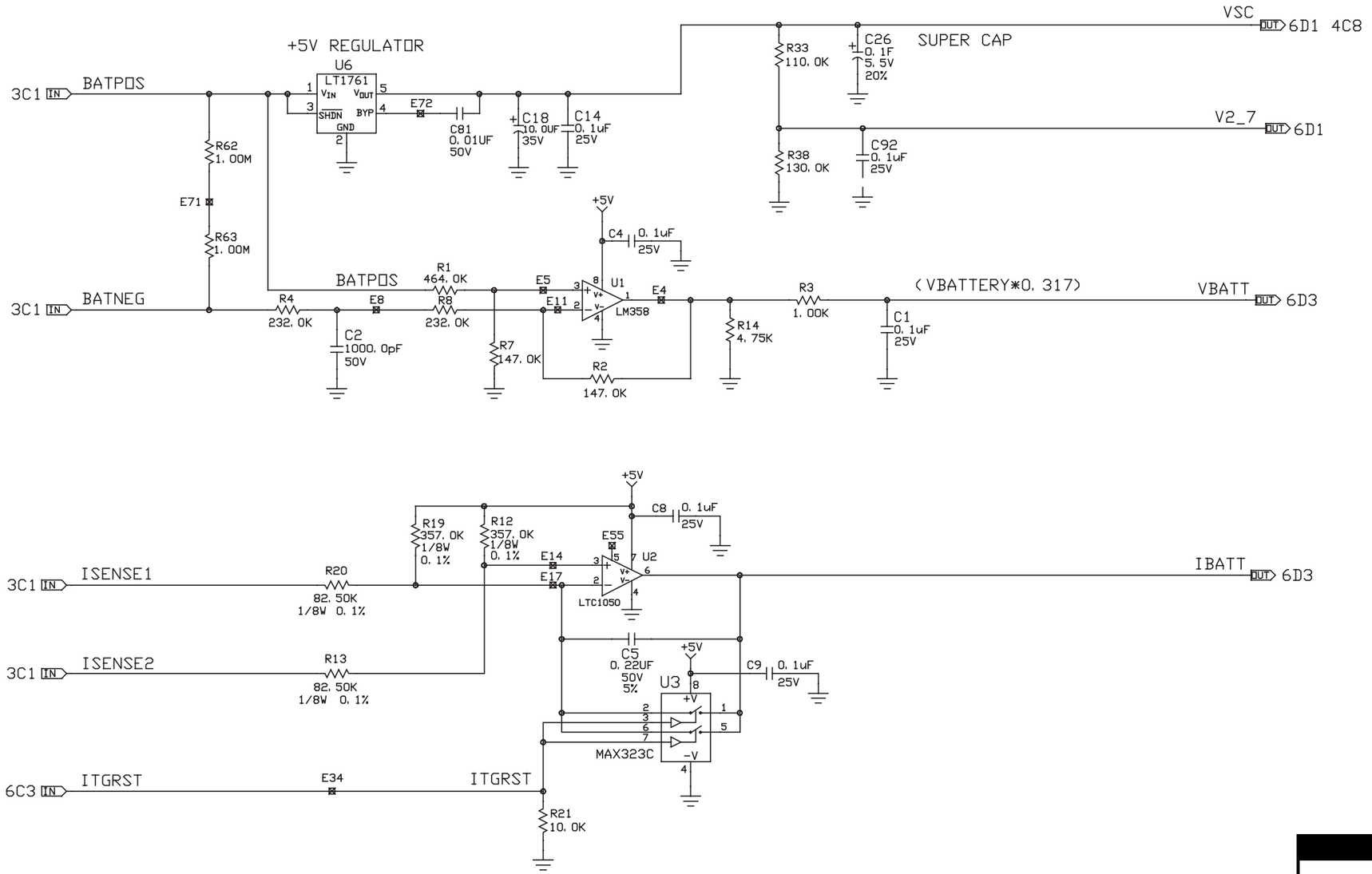

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Figure 9-10. Power Supply PWA Schematic	
DRAWING NO. 249-95242-014	Rev. A Sheet 4 of 5

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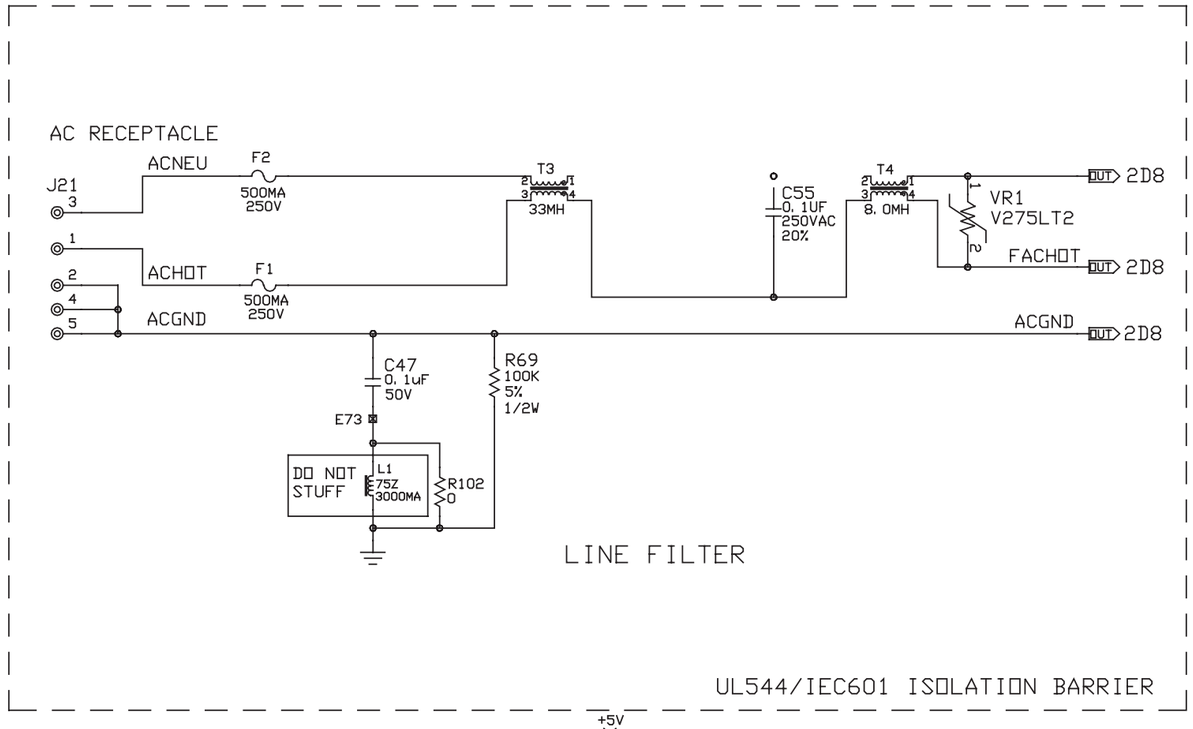

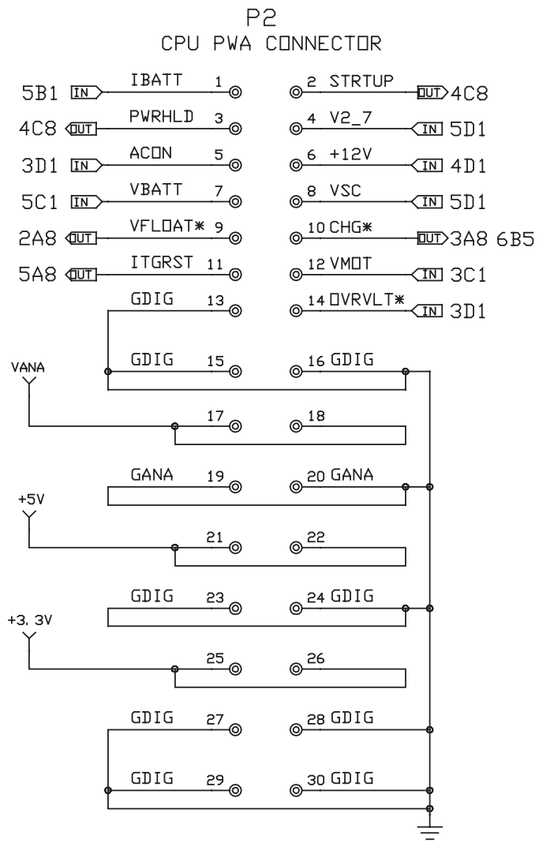

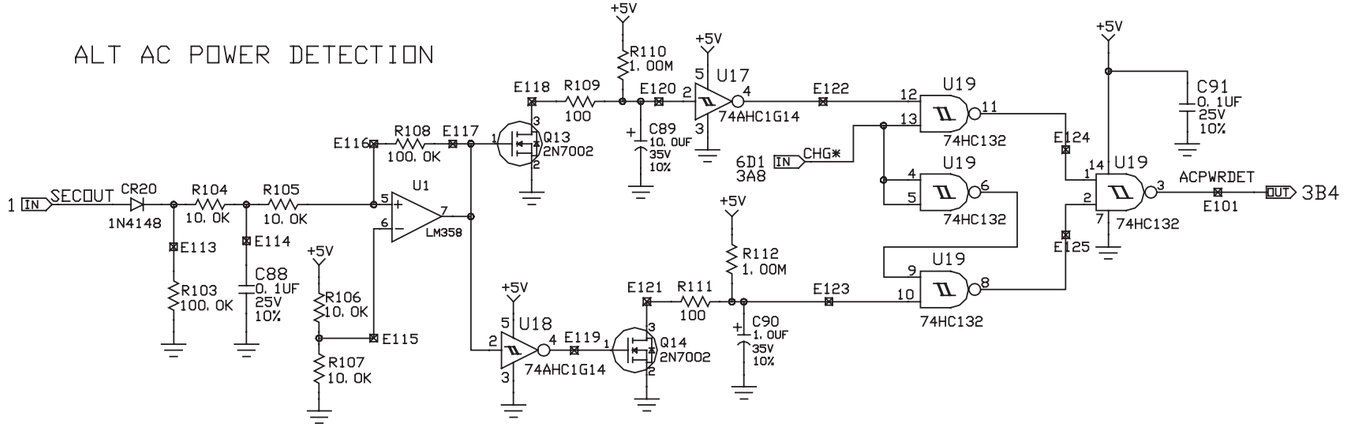

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Figure 9-10. Power Supply PWA Schematic	
DRAWING NO. 249-95242-014	Rev. A Sheet 5 of 5

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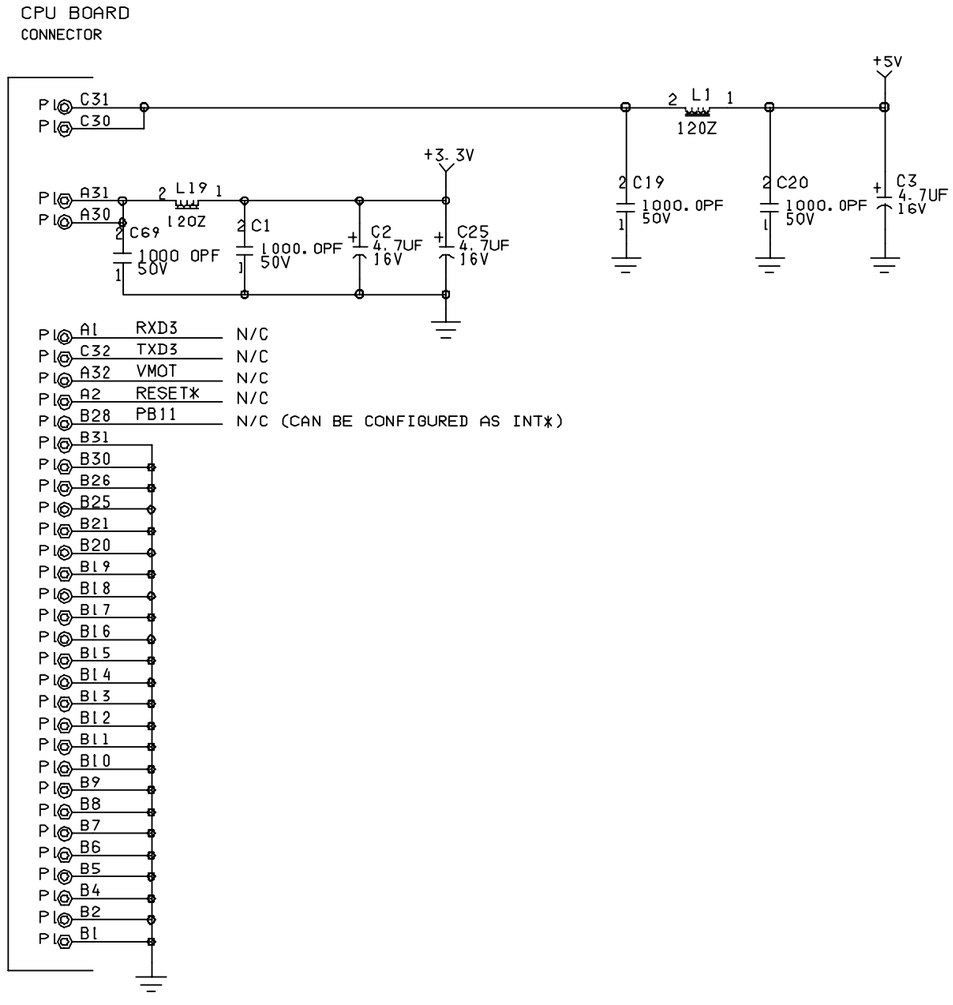

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Figure 9-11. Peripheral PWA Schematic	
DRAWING NO.	Rev. B
249-95006-011	Sheet 1 of 4

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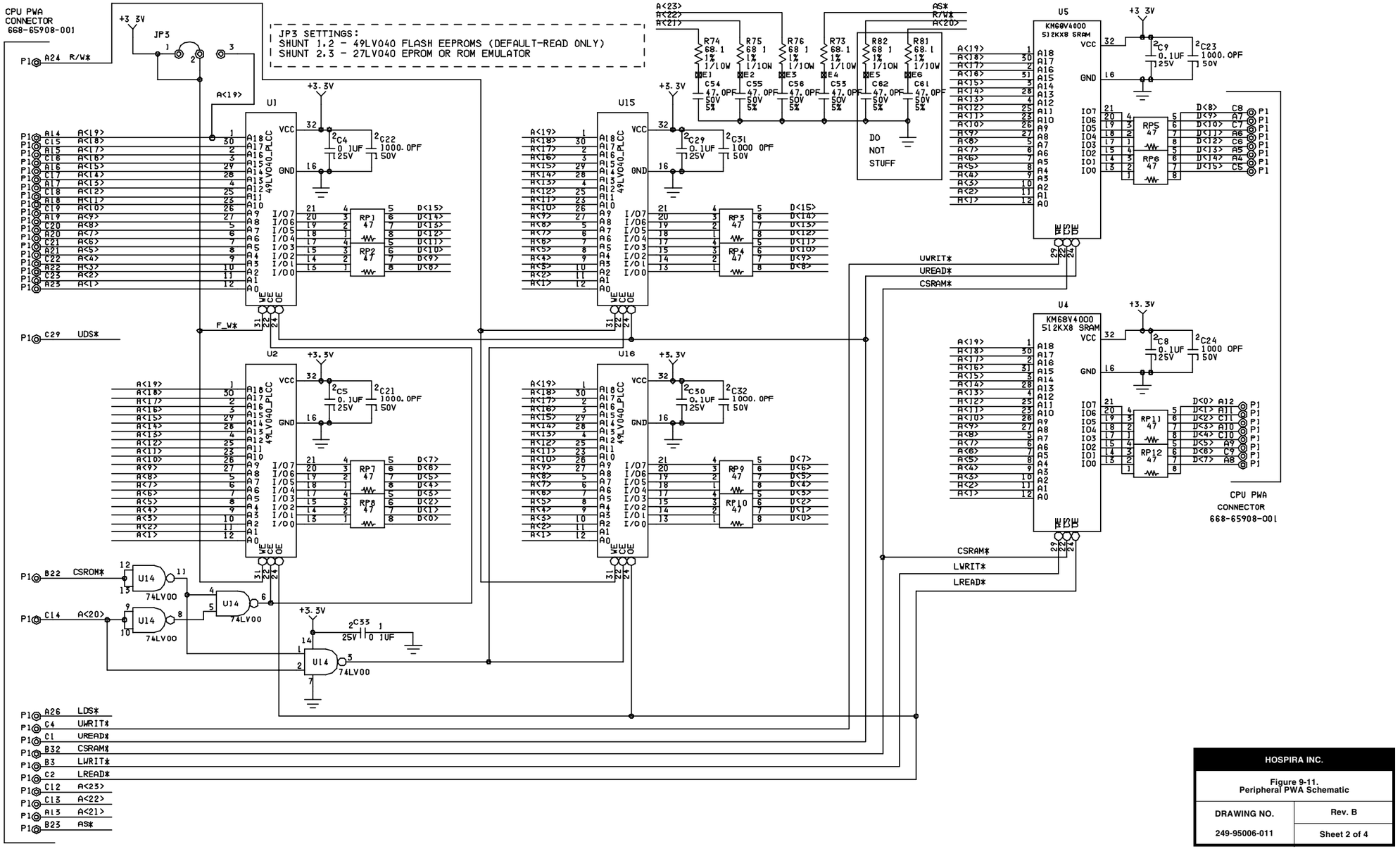

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Figure 9-11. Peripheral PWA Schematic	
DRAWING NO. 249-95006-011	Rev. B
	Sheet 2 of 4

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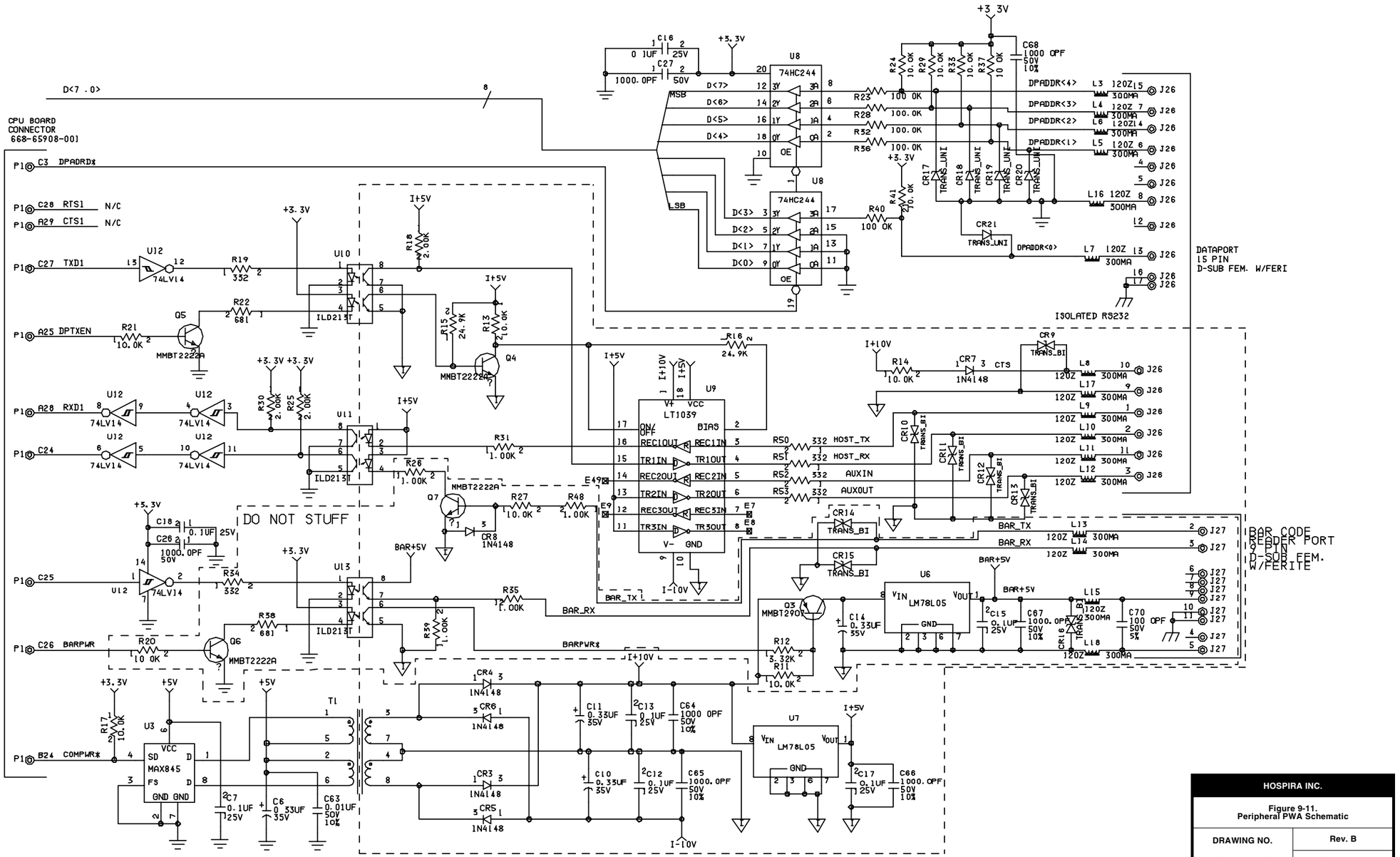

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Figure 9-11. Peripheral PWA Schematic	
DRAWING NO. 249-95006-011	Rev. B
	Sheet 3 of 4

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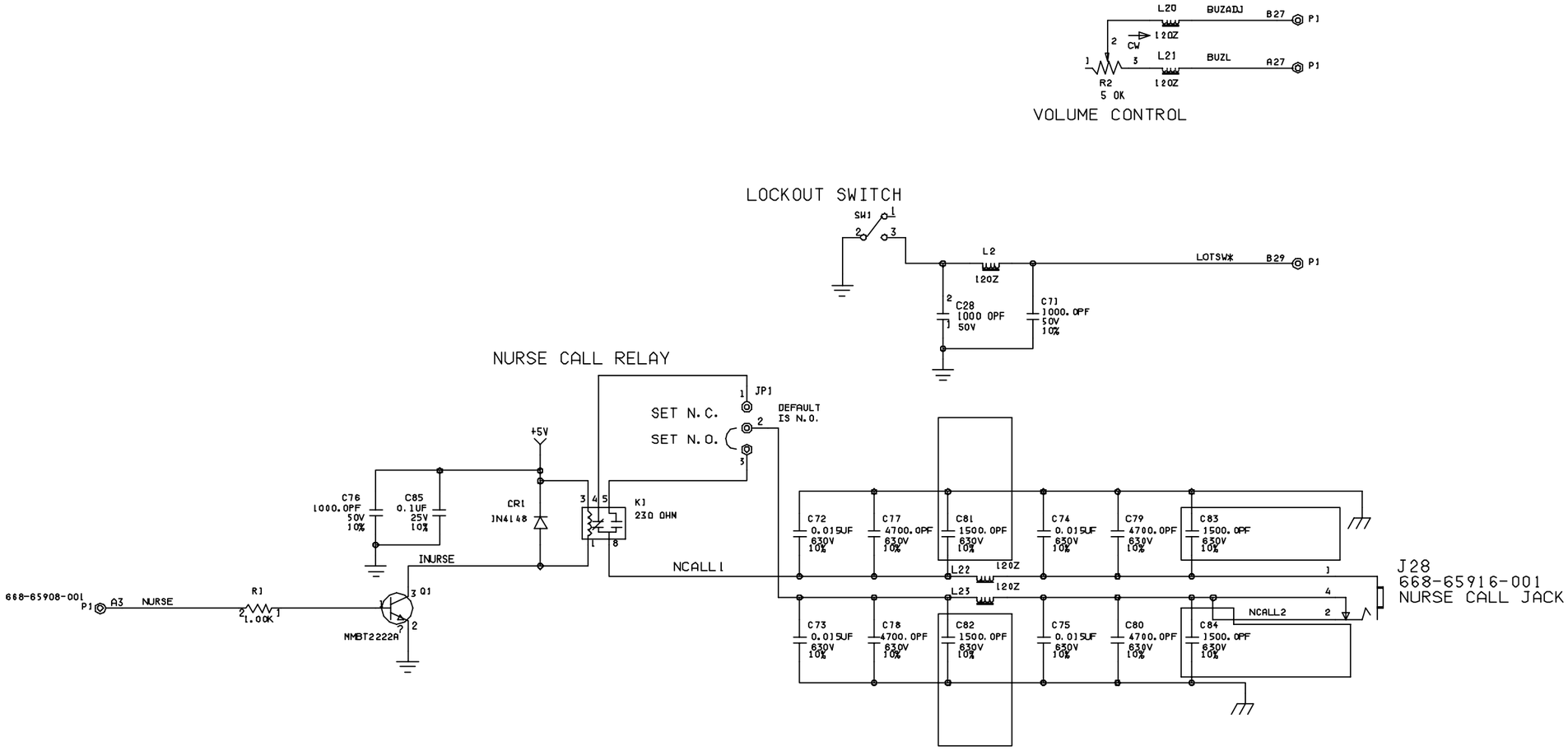

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Figure 9-11. Peripheral PWA Schematic	
DRAWING NO.	Rev. B
249-95006-011	Sheet 4 of 4

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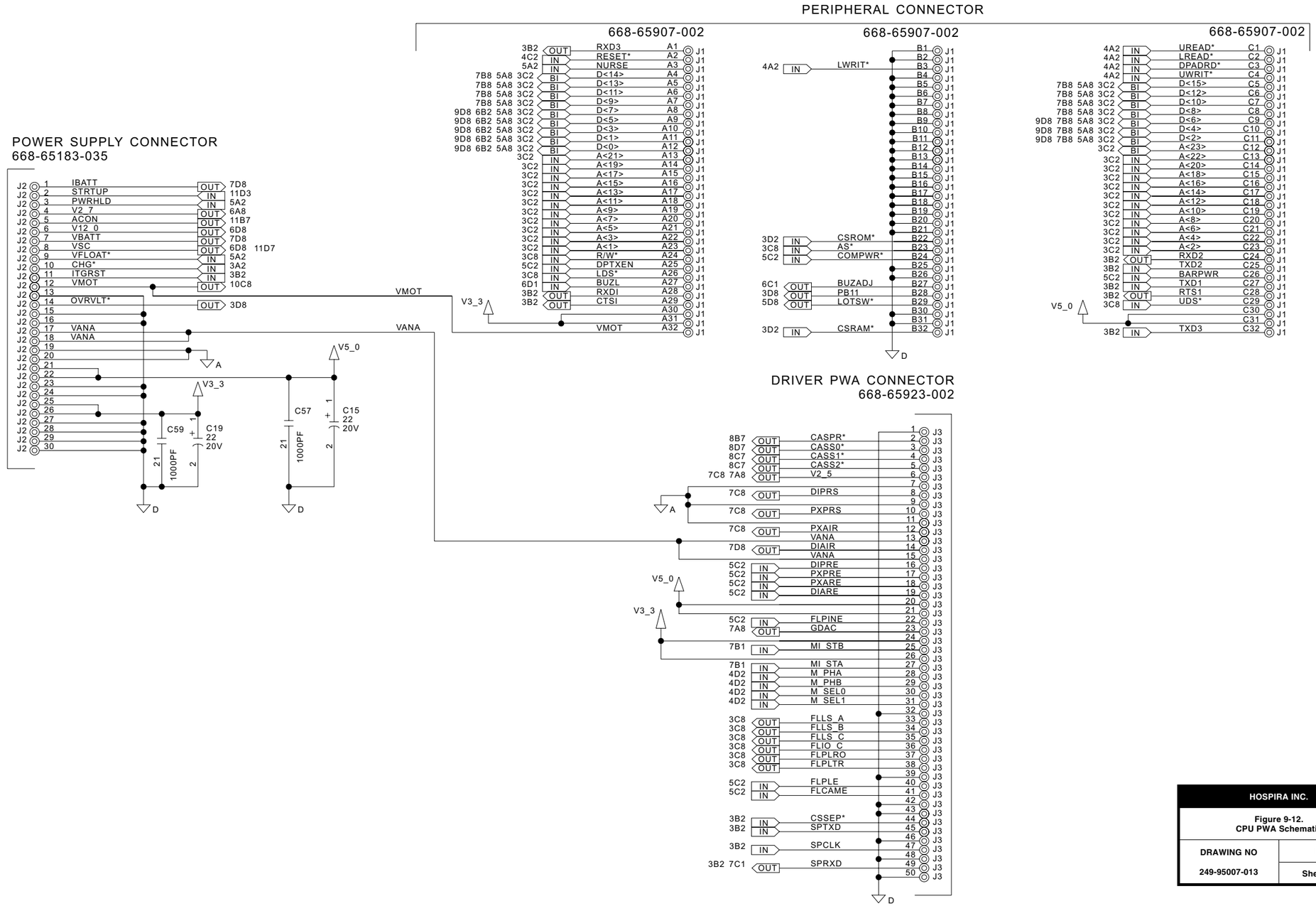

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Figure 9-12. CPU PWA Schematic	
DRAWING NO 249-95007-013	Rev. A Sheet 1 of 10

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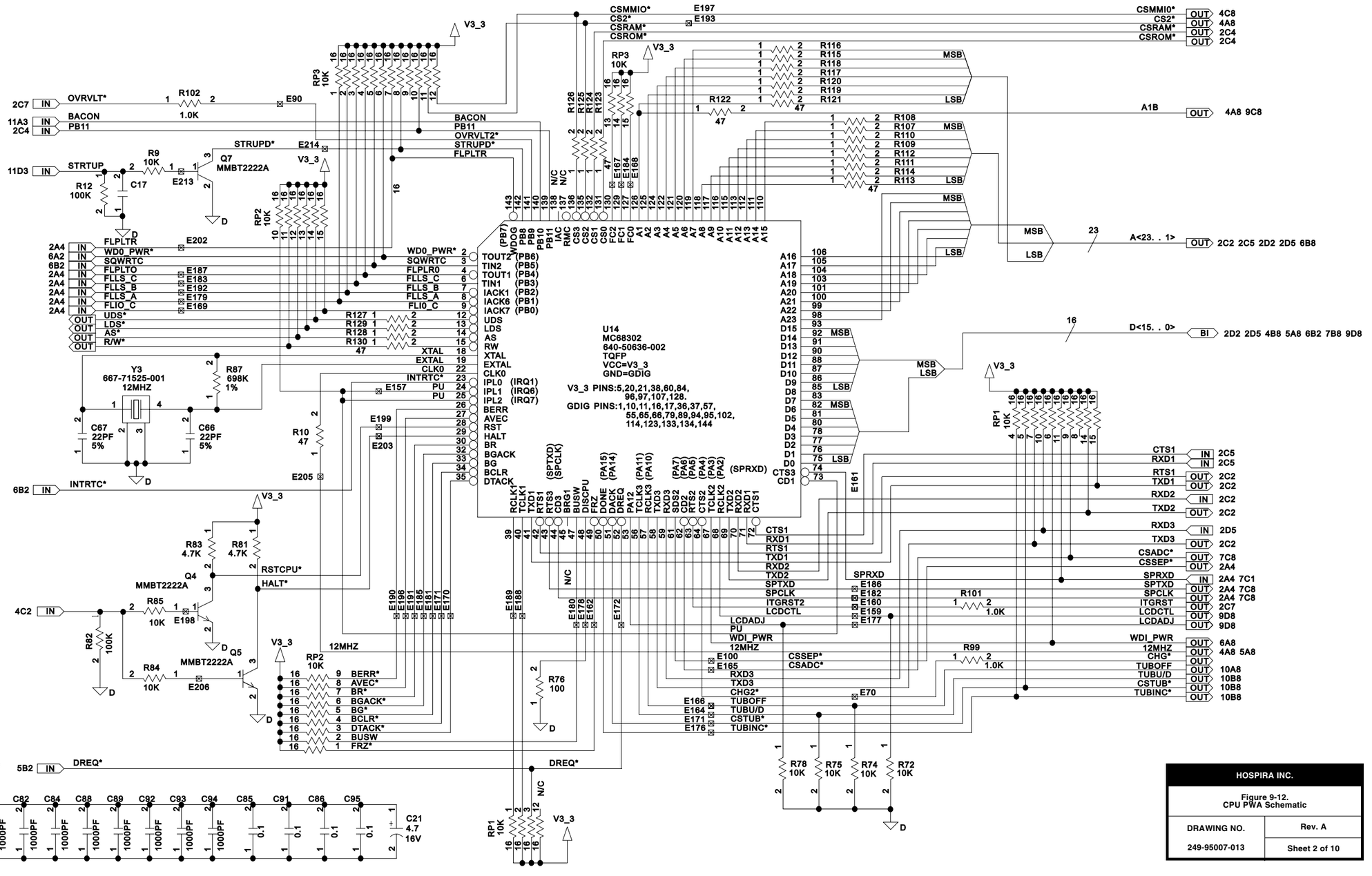

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Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 2 of 10

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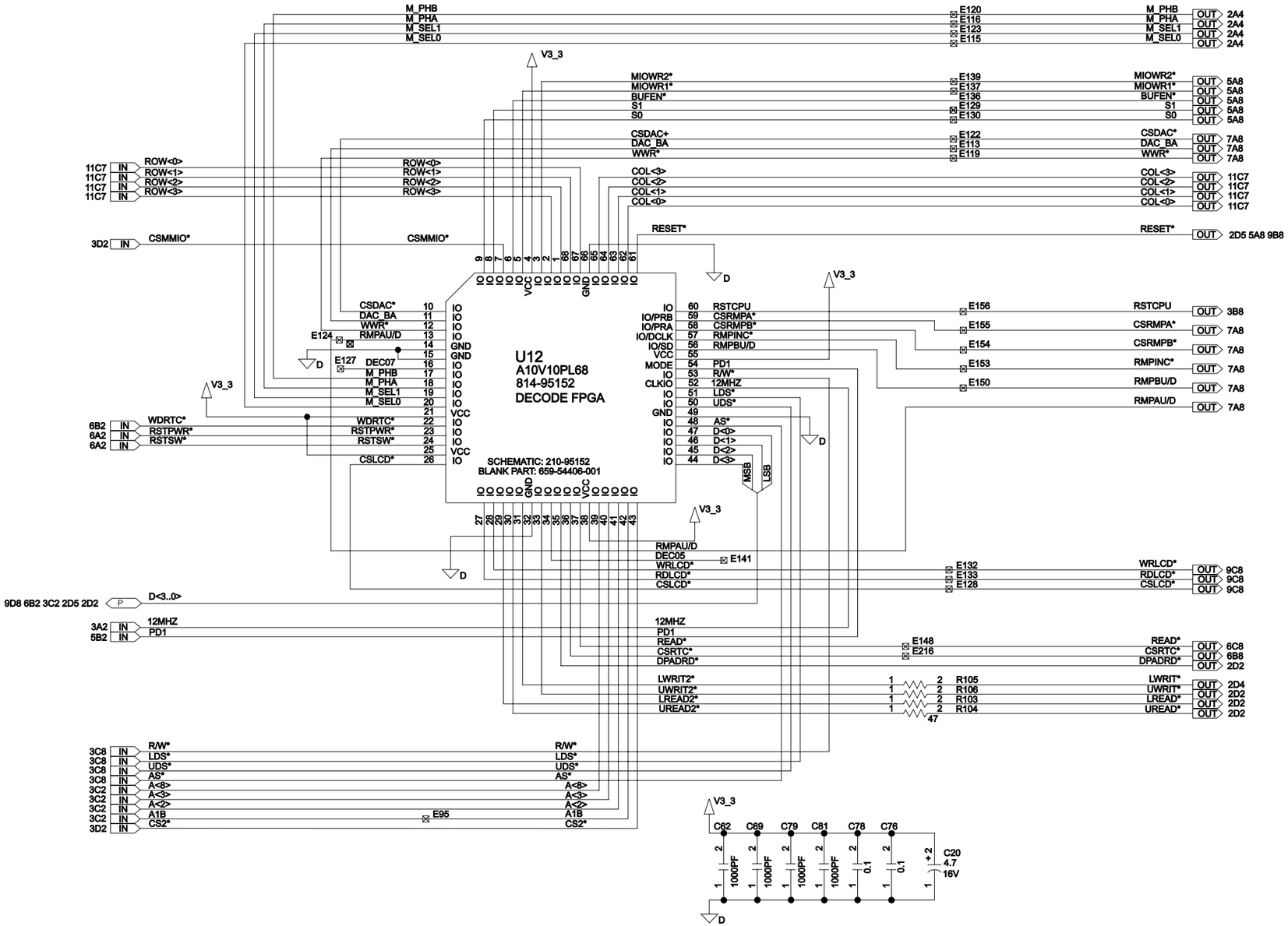

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Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 3 of 10

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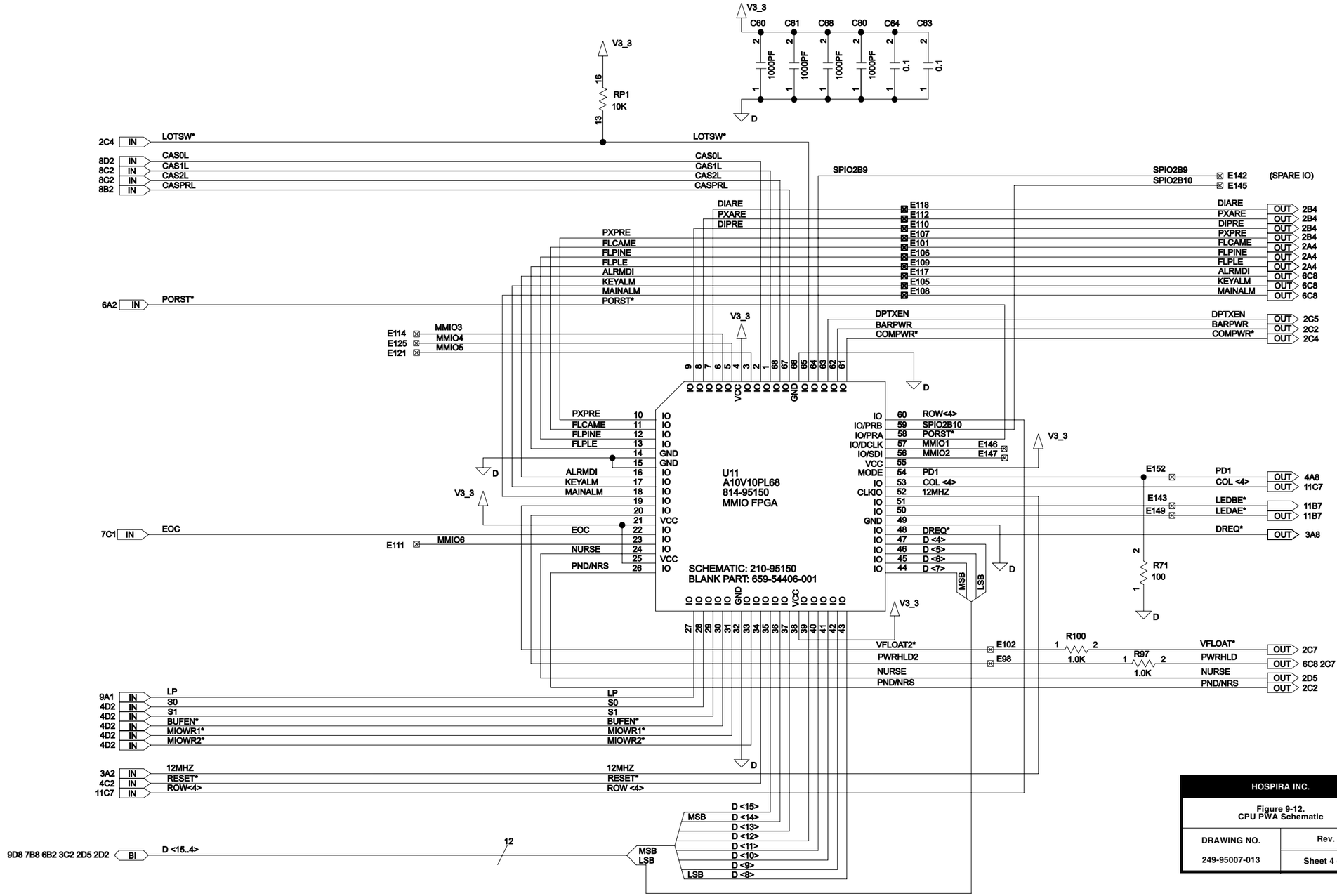

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Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 4 of 10

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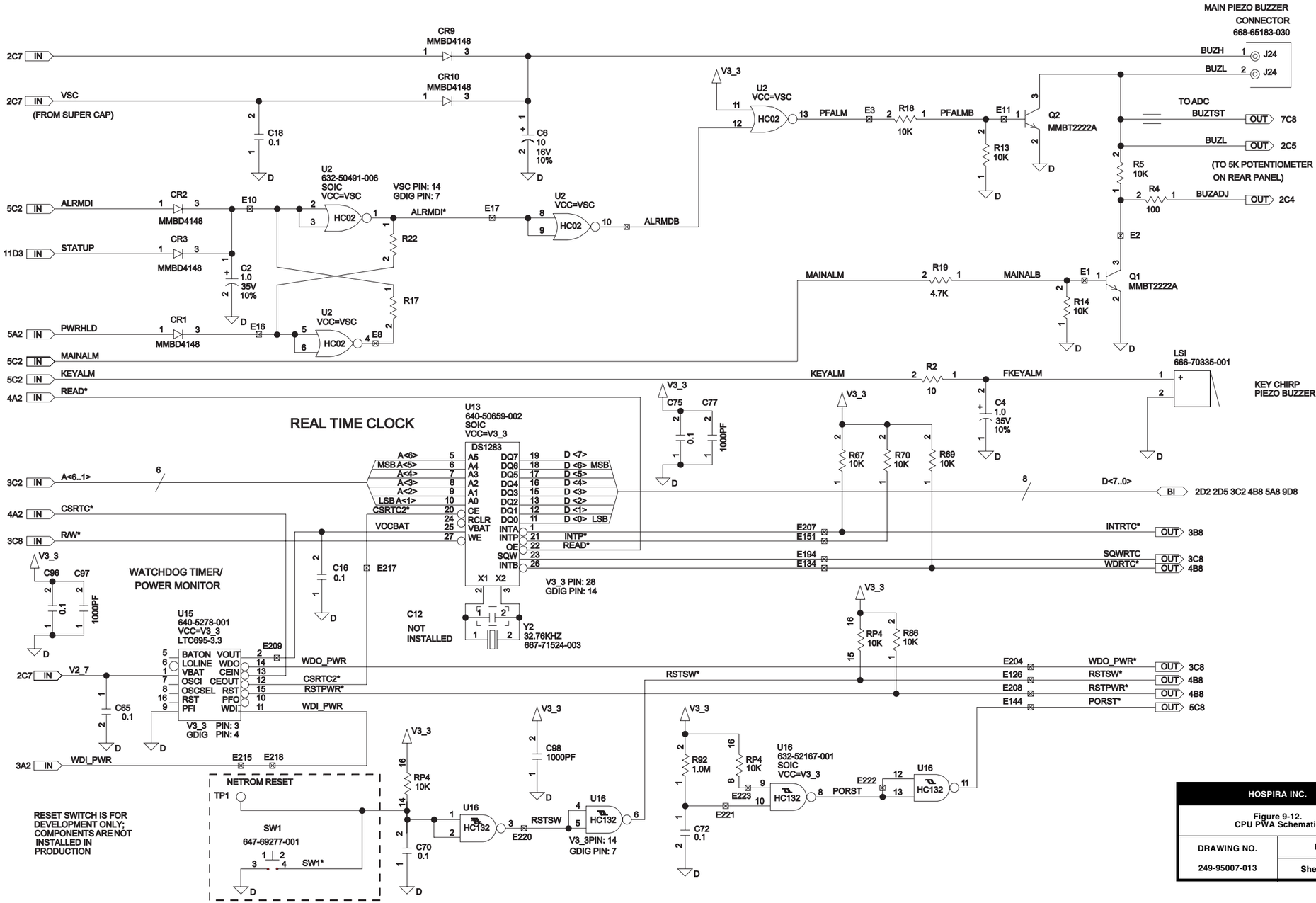

HOSPIRA INC.	
Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 5 of 10

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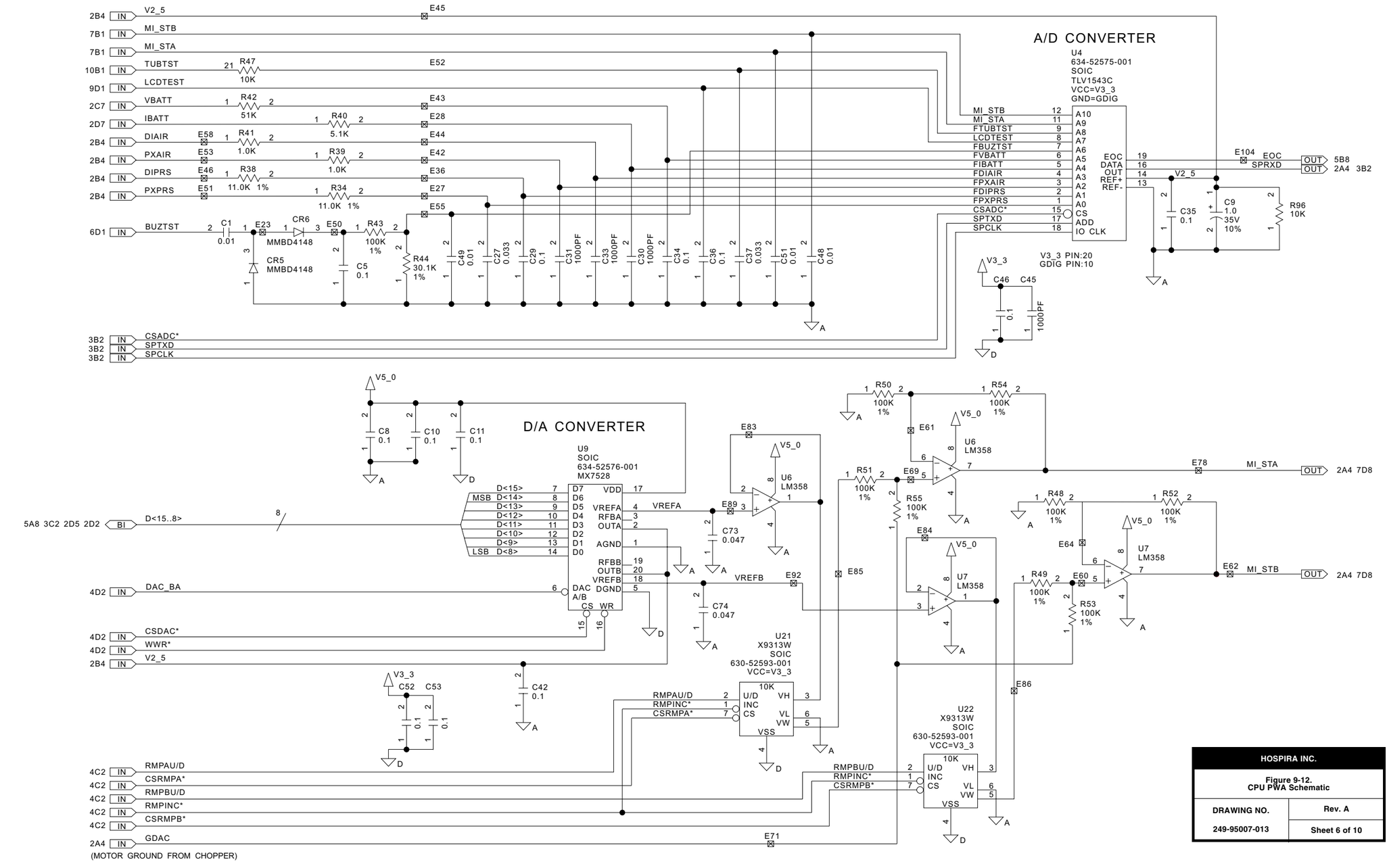

HOSPIRA INC.	
Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 6 of 10

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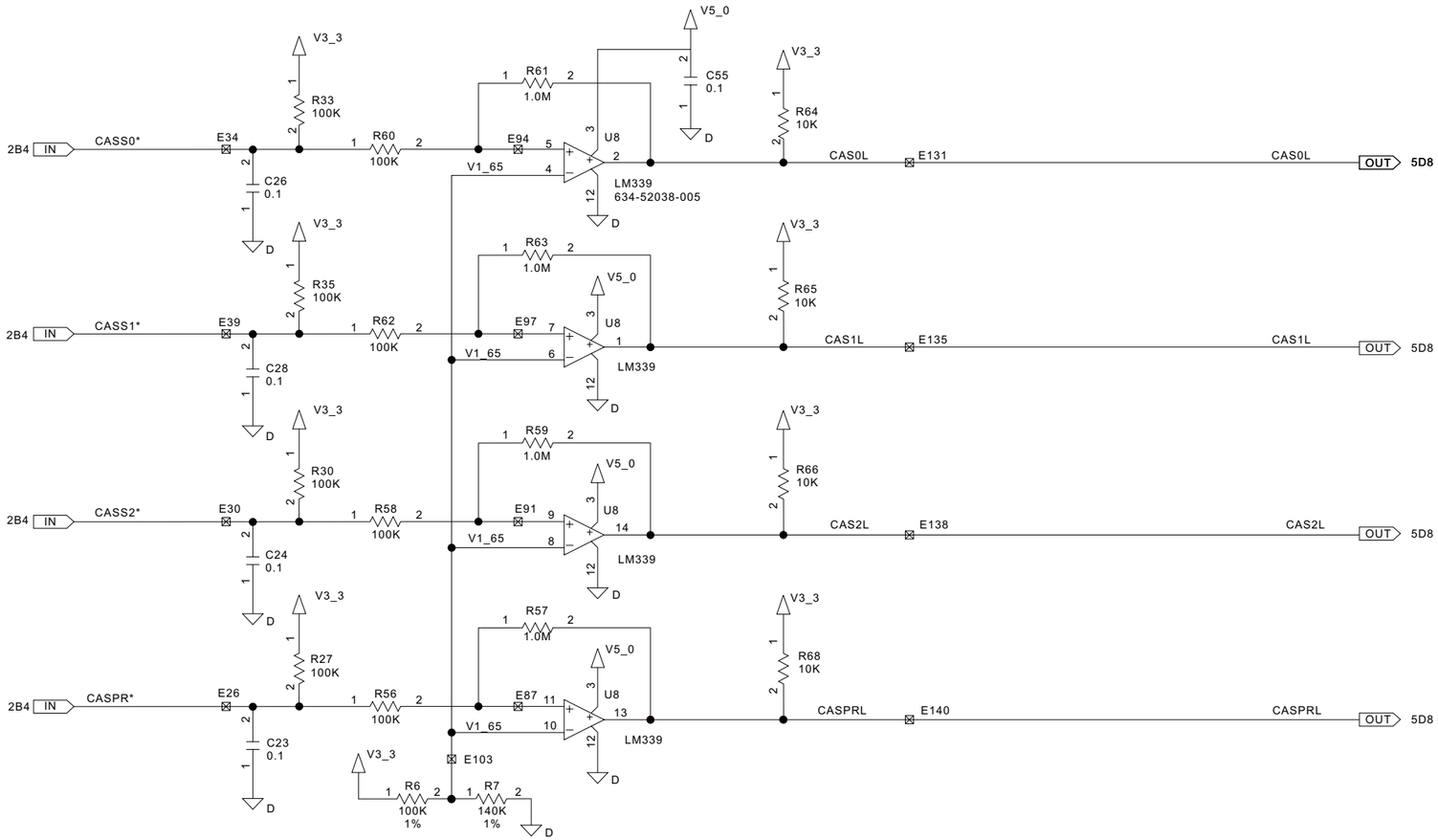

HOSPIRA INC.	
Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 7 of 10

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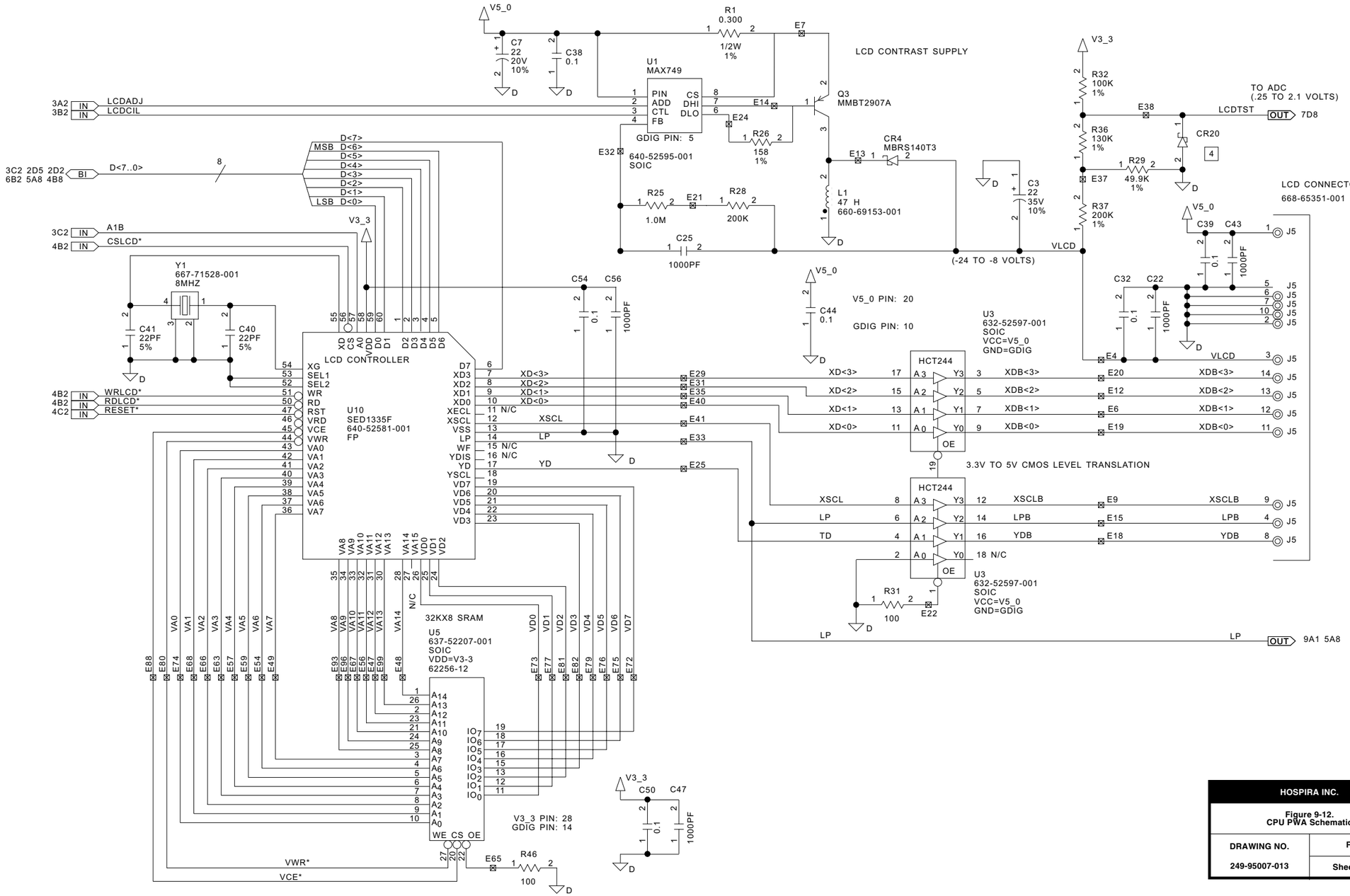

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Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 8 of 10

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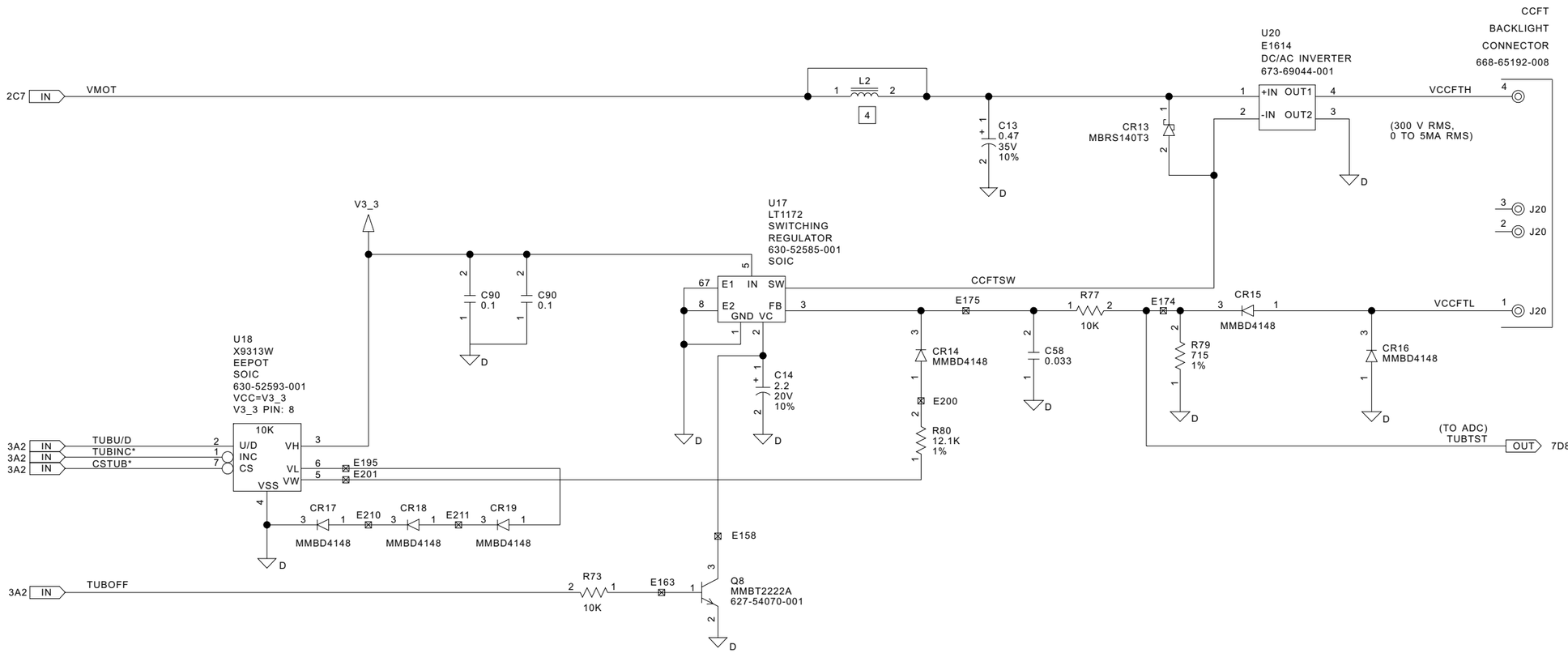

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Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 9 of 10

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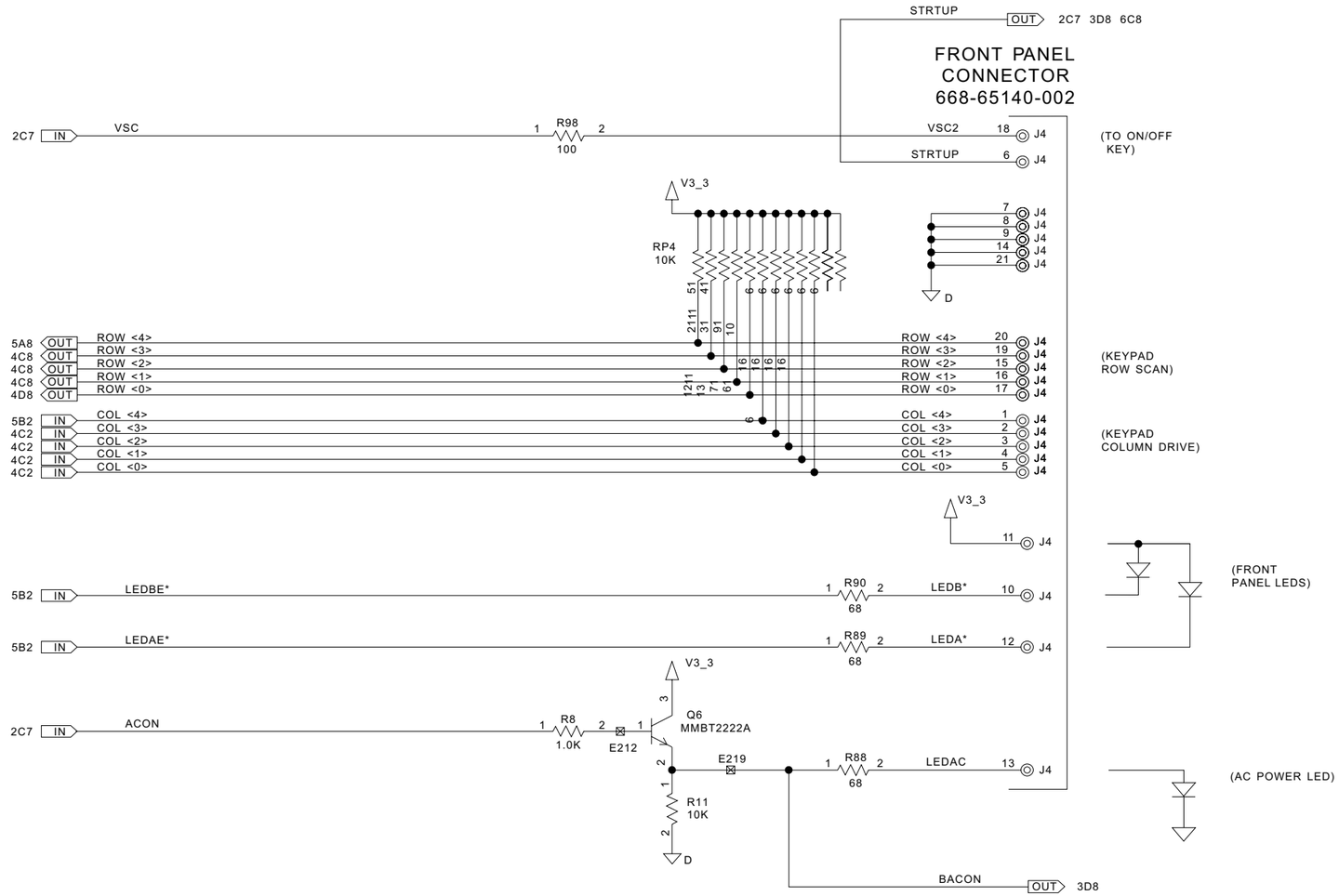

HOSPIRA INC.	
Figure 9-12. CPU PWA Schematic	
DRAWING NO. 249-95007-013	Rev. A Sheet 10 of 10

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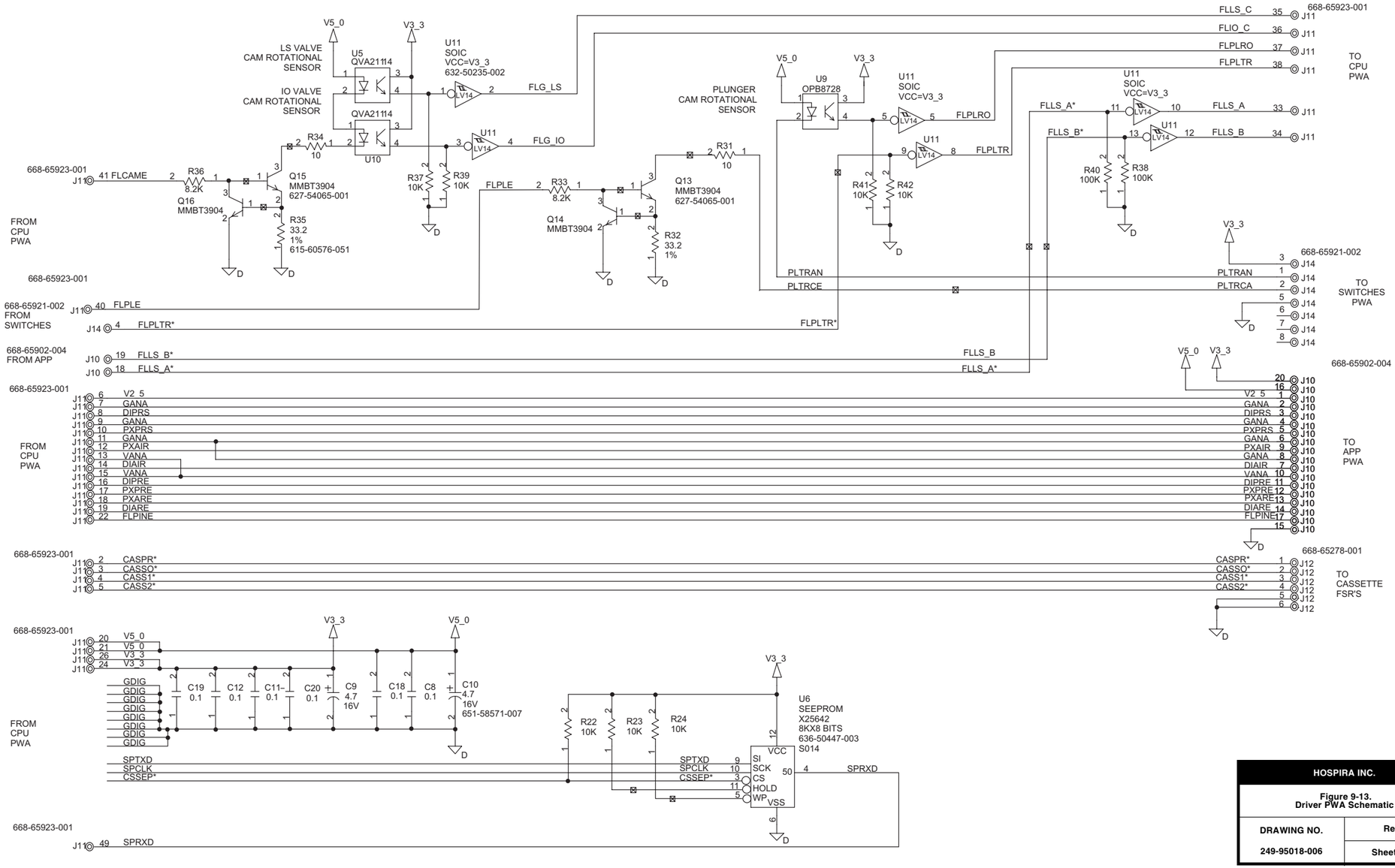

HOSPIRA INC.	
Figure 9-13. Driver PWA Schematic	
DRAWING NO.	Rev. E
249-95018-006	Sheet 1 of 3

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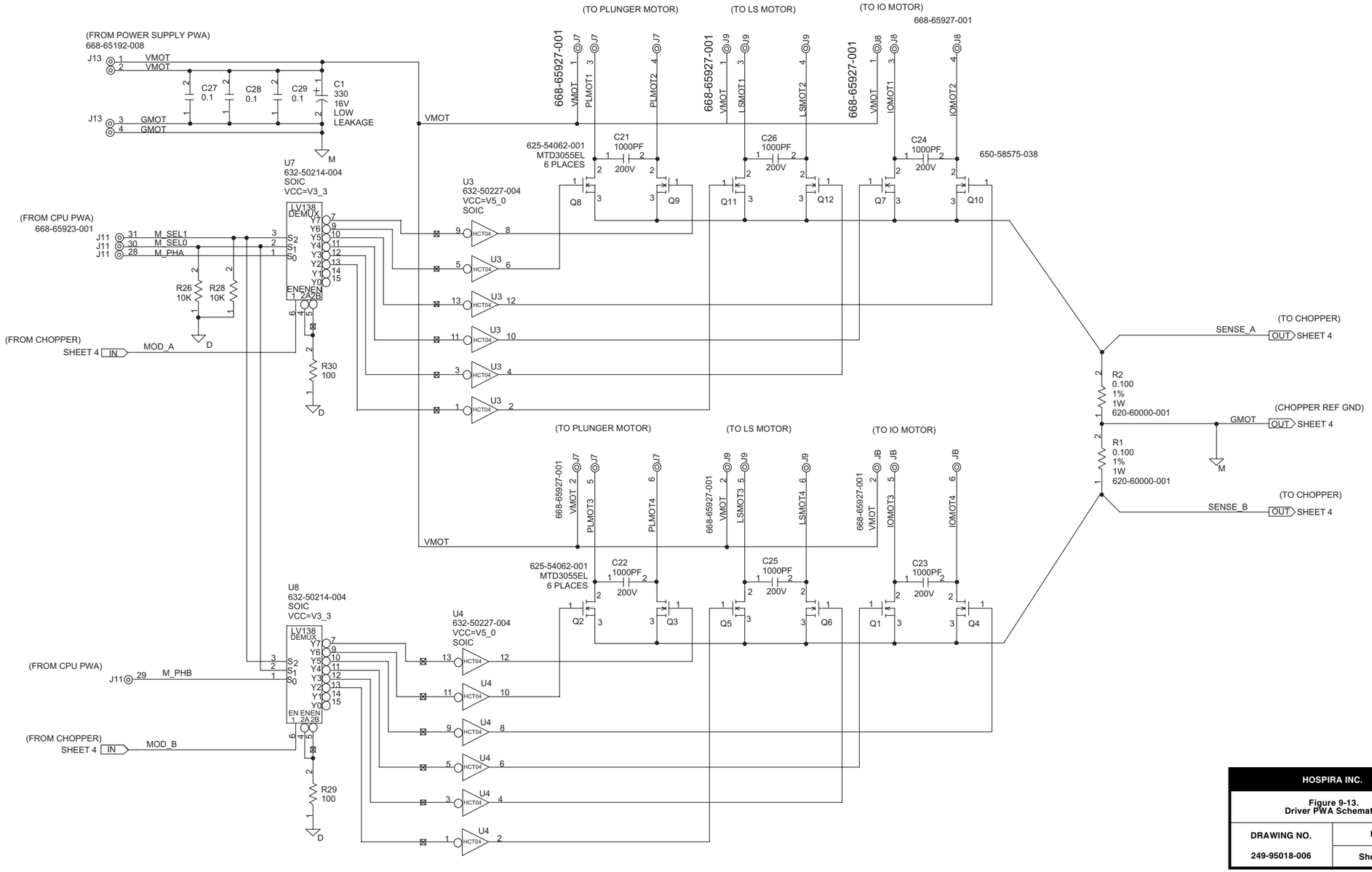

HOSPIRA INC.	
Figure 9-13. Driver PWA Schematic	
DRAWING NO. 249-95018-006	Rev. E Sheet 2 of 3

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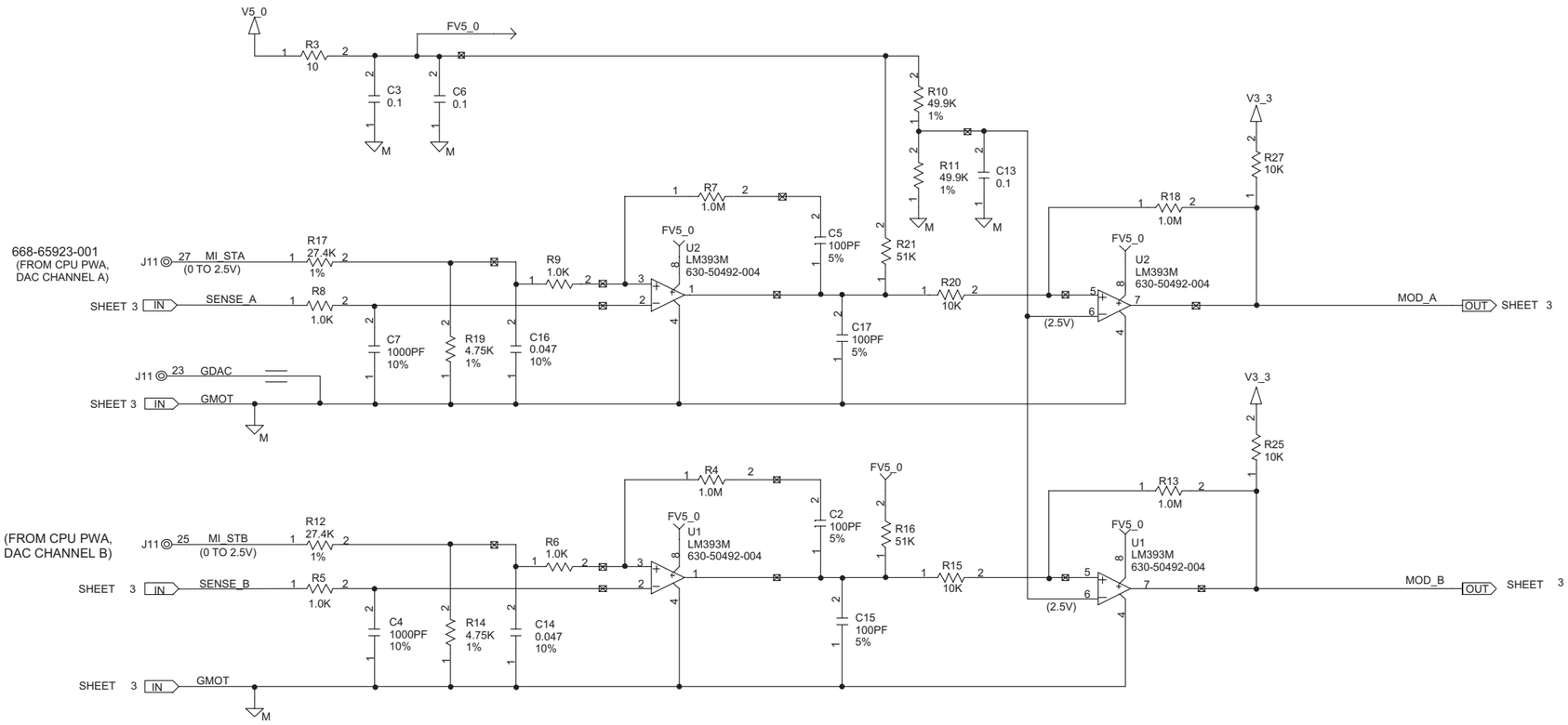

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Figure 9-13. Driver PWA Schematic	
DRAWING NO. 249-95018-006	Rev. E Sheet 3 of 3

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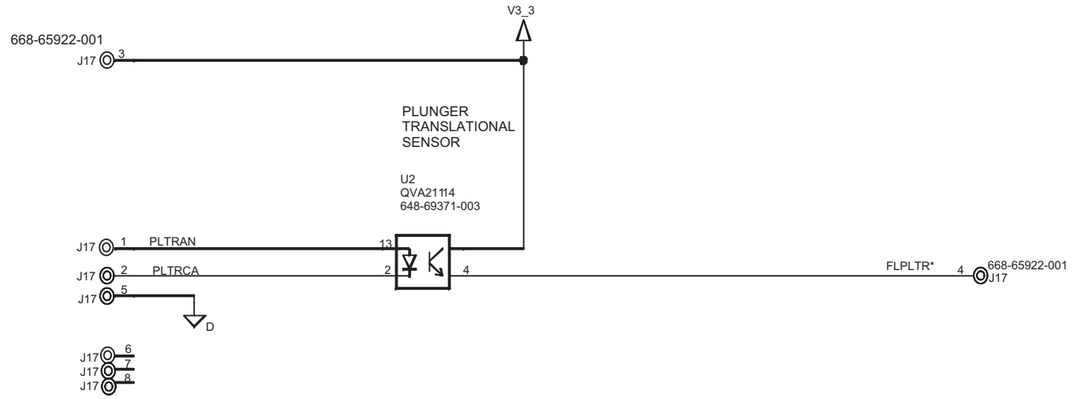

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Figure 9-14. Switch PWA Schematic	
DRAWING NO. 249-95022-004	Rev. C Sheet 1 of 1

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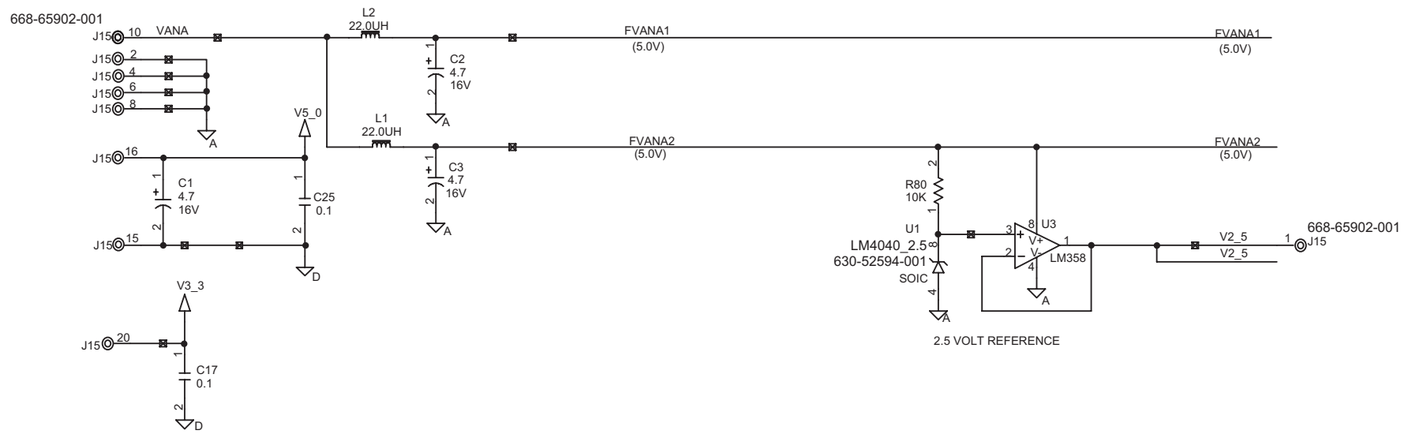

HOSPIRA INC.	
Figure 9-15. APP PWA Schematic	
DRAWING NO. 249-95034-009	Rev. F Sheet 1 of 3

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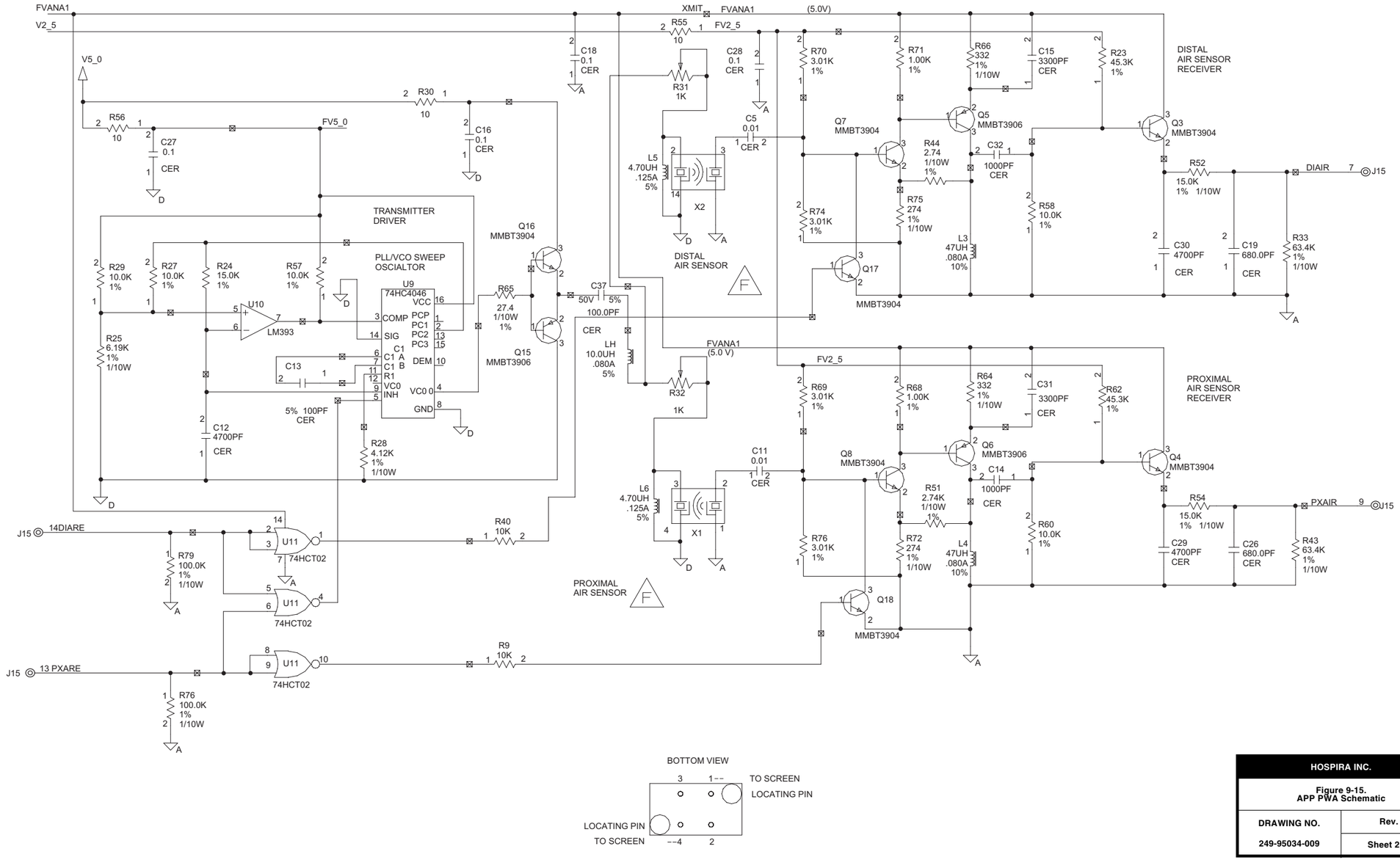

HOSPIRA INC.	
Figure 9-15. APP PWA Schematic	
DRAWING NO. 249-95034-009	Rev. F Sheet 2 of 3

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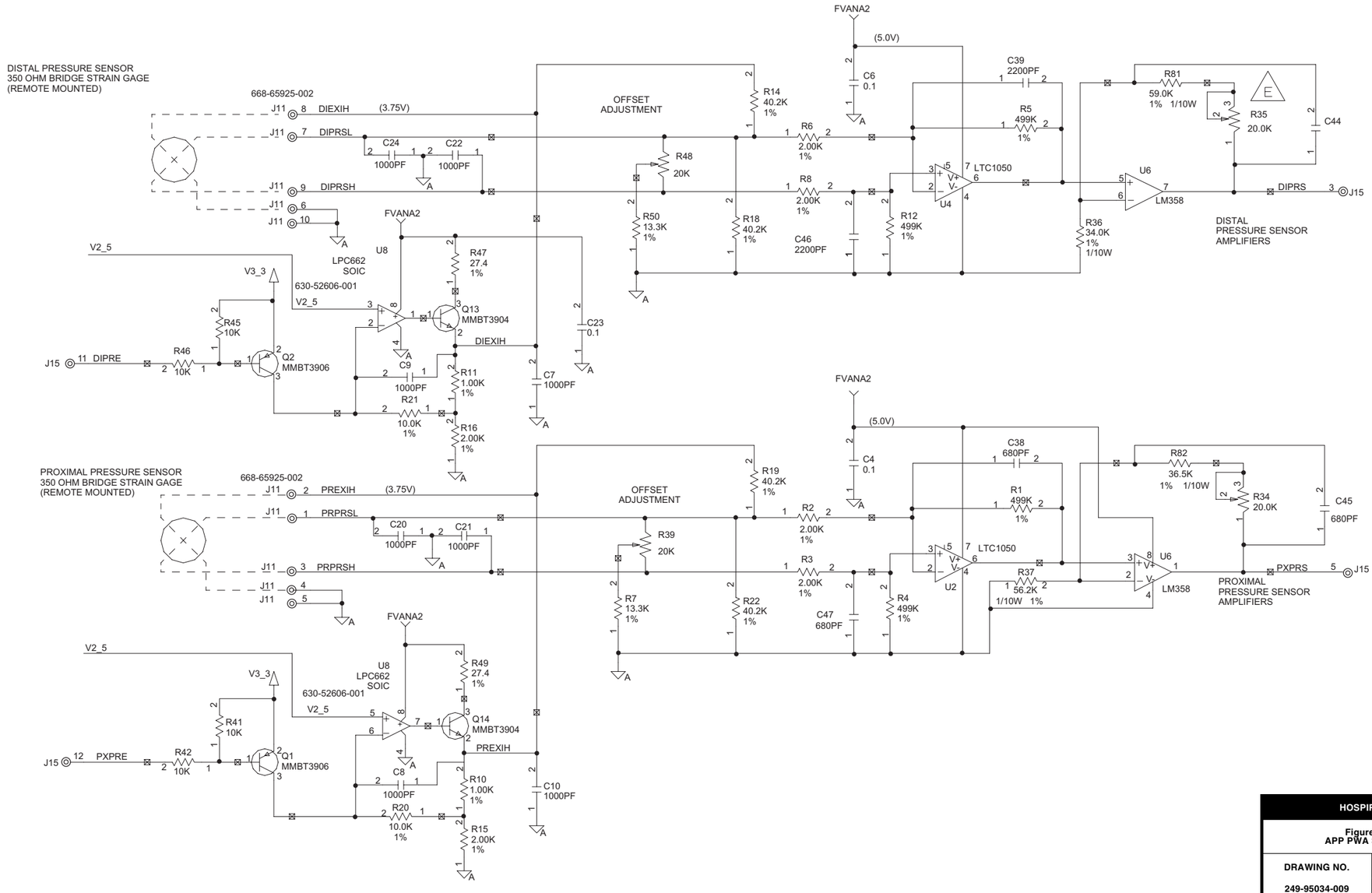

HOSPIRA INC.	
Figure 9-15. APP PWA Schematic	
DRAWING NO.	Rev. F
249-95034-009	Sheet 3 of 3

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INDEX

A

A/B valve subsystem, 4-31
AC power cord
  Replacement, 7-8
  Retainer, 7-8
Acronyms and abbreviations, 1-3
Air sensors, 4-19
  Receiver circuitry, 4-21
  Transmitter circuitry, 4-20
Air-in-line test
  Distal, 5-10
  Proximal, 5-10
Alarm loudness test, 5-8
Alarm messages and error codes, 6-2
  Error codes requiring technical service, 6-7
  Operational alarm messages, 6-2
Alarms log, 1-17
Amplifier and low pass filter, 4-23
Analog-to-digital converter, 4-6
APP PWA, 4-27
  Schematic, 9-73
Artifacts, 1-5
Audible indicators, 4-9
Auxiliary supplies, 4-14

B

Barcode reader
  Interface, 4-9
  Wand, 4-28
Battery
  Charge/discharge current measurement, 4-16
  Charger, 4-16
  Operation overview, 5-16
  Sealed lead acid, 4-28
  Voltage measurement, 4-16
Battery, battery door, and door pad replacement, 7-6
Biomed settings, 1-9
  Alarms log, 1-17
  IV parameters, 1-11
  Setting the time and date, 1-18
Bridge excitation supply, 4-22

C

Cassette, 4-28
  Alarm test, 5-6
Cassette door replacement, 7-34
Cassette type/presence selection, 4-23
Chopper motor drive, 4-18
Cleaning, 5-1
Cleaning solutions, 5-2
Common IV parameters, 1-12
Component designators, 1-2
Control logic, 4-3
Conventions, 1-2
CPU, 4-3
CPU PWA, 4-25
  Replacement, 7-29
  Schematic, 9-45
CPU subsystem, 4-2
  Analog-to-digital converter, 4-6
  Audible indicators, 4-9
  Barcode reader interface, 4-9
  Control logic, 4-3
  CPU, 4-3
  DataPort interface, 4-10
  Digital-to-analog converter, 4-8
  Front panel
    Keypad matrix, 4-8
    LED indicators, 4-8
    On/off key, 4-8
  Keypad lockout interface, 4-9
  LCD
    Backlight control, 4-4
    Contrast control, 4-4
    Controller, 4-4
  Mechanism interface, 4-11
  Nurse call interface, 4-9
  Power supply interface, 4-10
  Programmable read-only memory, 4-3
  Real-time clock, 4-5
  Static random access memory, 4-3
  System memory address map, 4-3
  Voltage monitor watchdog timer, 4-5
Current limit loop, 4-14

D

DataPort interface, 4-10
Default units/drug, 1-14
Delivery accuracy test, 5-14
Digital-to-analog converter, 4-8
Display test, 5-6
Display replacement, 7-28
Distal air-in-line test, 5-10
Distal occlusion test, 5-12
Drawings, 9-1
    AC power cord, retainer, and battery assembly, 9-21
    CPU PWA and main chassis, 9-23
    Front enclosure assembly, 9-9
    Front enclosure, rear enclosure, and main chassis, 9-7
    Illustrated parts breakdown, 9-5
    Main chassis assembly, 9-15
    Mechanism assembly, 9-25
    Peripheral assembly, 9-13
    Rear enclosure assembly, 9-11
Driver PWA, 4-26
    Schematic, 9-65

E

Electrical safety test, 5-15
Electronic subsystem overview, 4-2
    CPU subsystem, 4-2
    Mechanism subsystem, 4-17
    Power supply subsystem, 4-13
End of the PVT, 5-15
Equipment precautions, 7-3
Equipment required, 5-3
Error codes requiring technical service, 6-7

F

Fluid shield replacement, 7-34
Free flow test, 5-6
Front enclosure
    Replacement, 7-17
    Separating, 7-15
Front panel
    Keypad matrix, 4-8
    LED indicators, 4-8
    On/off key, 4-8
Front/rear enclosure gasket replacement, 7-18

G

Gasket replacement
    Front/rear enclosure, 7-18
    Handle, 7-22
    Rear enclosure, 7-22
    Shoe, 7-18
General description, 4-1

H

Handle gasket replacement, 7-22
Hospira, 6-1

I

Illustrated parts breakdown, 9-2, 9-5
Inlet/outlet valve subsystem, 4-32
Inspection, 1-6, 5-3
Instrument installation procedure, 1-6
    Inspection, 1-6
    Self test, 1-7
    Unpacking, 1-6
Introduction, 1-1
IV parameters, 1-11
    Common IV parameters, 1-12
    Default units/drug, 1-14
    Macro IV parameters, 1-16

K

Keypad
    Lockout interface, 4-9
    Replacement, 7-27
    Verification/functional test, 5-7

L

LCD, 4-27
    Backlight control, 4-4
    Contrast control, 4-4
    Controller, 4-4
Lockout switch test, 5-9

M

Macro IV parameters, 1-16
Main chassis assembly
  Component replacement, 7-25
  Replacement, 7-17
  Separating, 7-15
Main loop, 4-13
Main regulator fault detection, 4-14
Main switching regulator, 4-13
  Current limit loop, 4-14
  Main loop, 4-13
  Secondary loop, 4-14
Maintenance and service tests, 5-1
  Battery operation overview, 5-16
  Performance verification test, 5-2
  Periodic maintenance inspection, 5-15
  Routine maintenance, 5-1
Mechanical overview, 4-28
  Cassette, 4-28
Mechanism assembly, 4-30
  A/B valve subsystem, 4-31
  Inlet/outlet valve subsystem, 4-32
  Motor and valve assemblies, 4-30
  Plunger drive subsystem, 4-32
  Replacement, 7-32
Mechanism interface, 4-11
Mechanism subsystem, 4-17
  Air sensors, 4-19
  Cassette type/presence selection, 4-23
  Motor position sensors, 4-18
  Motors/motor drive, 4-17
  Pressure sensor calibration, 4-23
  Pressure sensors, 4-21
  Serial EEPROM, 4-23
  V2_5 reference voltage, 4-19
Minipole assembly
  Bag hanger, 7-24
  Clutch housing, 7-24
  Clutch spring, 7-25
  Cotter ring, 7-23
  Replacement, 7-22
Motor and valve assemblies, 4-30
Motor position sensors, 4-18
Motors/motor drive, 4-17
  Chopper motor drive, 4-18
  Stepper motors, 4-17

N

Nurse call
  Interface, 4-9
  Test, 5-14

O

Opener handle assembly
  replacement, 7-37
Operational alarm messages, 6-2

P

Performance verification test, 5-2
  Alarm loudness test, 5-7
  Cassette alarm test, 5-6
  Delivery accuracy test, 5-14
  Display test, 5-6
  Distal air-in-line test, 5-10
  Distal occlusion test, 5-12
  Electrical safety test, 5-15
  End of the PVT, 5-15
  Equipment required, 5-3
  Free flow test, 5-6
  Inspection, 5-3
  Keypad verification/
    functional test, 5-7
  Lockout switch test, 5-9
  Nurse call test, 5-14
  Proximal air-in-line test, 5-10
  Proximal occlusion test, 5-9
  Self test, 5-4
  Test setup, 5-4
Periodic maintenance inspection, 5-15
Peripheral assembly
  Component replacement, 7-12
  Replacement, 7-10
Peripheral cover replacement, 7-14
Peripheral PWA, 4-25
  Schematic, 9-37
Piezo alarm replacement, 7-31
Plunger drive subsystem, 4-32
Pole clamp
  Backing plate replacement, 7-21
  Extrusion replacement, 7-21
  Shaft/knob assembly
    replacement, 7-21
  Shaft tip replacement, 7-21
Power control, 4-15
Power supply interface, 4-10
Power supply PWA, 4-24
  Replacement, 7-27
  Schematic, 9-27
Power supply subsystem, 4-13
  Auxiliary supplies, 4-14
  Battery charge/discharge
    current measurement, 4-16
  Battery charger, 4-16
  Battery voltage measurement, 4-16
  Main regulator fault detection, 4-14

Main switching regulator, 4-13
Power control, 4-15
System power, 4-14
Pressure sensor calibration, 4-23
Pressure sensors, 4-21
Amplifier and low pass filter, 4-23
Bridge excitation supply, 4-22
Printed wiring assemblies, 4-24
APP, 4-27
CPU, 4-25
Driver, 4-26
Peripheral, 4-25
Power supply, 4-24
Switch, 4-27
Programmable read-only memory, 4-3
Proximal air-in-line test, 5-10
Proximal occlusion test, 5-9

R

Real-time clock, 4-5
Rear enclosure and handle gaskets replacement, 7-22
Rear enclosure
Component replacement, 7-19
Replacement, 7-17
Separating, 7-15
Receiver circuitry, 4-21
Remote mounted peripherals, 4-27
Barcode reader wand, 4-28
LCD, 4-27
Sealed lead acid battery, 4-28
Replaceable parts and repairs, 7-1
Replacement procedures, 7-3
AC power cord, 7-8
AC power cord retainer, 7-8
Battery, battery door, and door pad, 7-6
Cassette door, 7-34
CPU PWA, 7-29
Display, 7-28
Fluid shield, 7-34
Front enclosure, 7-17
Front/rear enclosure gasket, 7-18
Handle gasket, 7-22
Keypad, 7-27
Main chassis assembly, 7-17
Components, 7-25
Mechanism assembly, 7-32
Minipole assembly, 7-22
Bag hanger, 7-24
Clutch housing, 7-24
Clutch spring, 7-25
Cotter ring, 7-23
Opener handle assembly, 7-37
Peripheral assembly, 7-10
Peripheral assembly components, 7-12
Peripheral cover, 7-14
Piezo alarm, 7-31
Pole clamp
Backing plate, 7-21
Extrusion, 7-21
Shaft/knob, 7-21
Shaft tip, 7-21
Power supply PWA, 7-27
Rear enclosure, 7-17
Components, 7-19
Rear enclosure gasket, 7-22
Required tools and materials, 7-3
Rubber foot pad, 7-4
Safety and equipment precautions, 7-3
Shoe gaskets, 7-18
Velcro strap, 7-8
Volume control knob, 7-14
Required tools and materials, 7-3
Routine maintenance, 5-1
Cleaning, 5-1
Sanitizing, 5-2
Rubber foot pad replacement, 7-4

S

Safety precautions, 7-3
Sanitizing, 5-2
Schematics
APP PWA, 9-73
CPU PWA, 9-45
Driver PWA, 9-65
Peripheral PWA, 9-37
Power supply PWA, 9-27
Switch PWA, 9-71
Scope, 1-1
Sealed lead acid battery, 4-28
Secondary loop, 4-14
Self test, 1-7, 5-4
Separating the front enclosure, rear enclosure, and main chassis assembly, 7-15
Serial EEPROM, 4-23
Setting the time and date, 1-18
Shoe gasket replacement, 7-18
Specifications, 8-1
Static random access memory, 4-3
Stepper motors, 4-17
Switch PWA, 4-27
Schematic, 9-71
System memory address map, 4-3
System operating manual, 3-1
System power, 4-14

T

Technical assistance, 6-1
Test setup, 5-4
Tests
    Alarm loudness, 5-7
    Cassette alarm, 5-6
    Delivery accuracy, 5-14
    Display, 5-6
    Distal air-in-line, 5-10
    Distal occlusion, 5-12
    Electrical safety, 5-15
    Free flow, 5-6
    Keypad verification/
      functional, 5-7
    Lockout switch, 5-9
    Nurse call, 5-14
    Performance verification, 5-2
    Proximal air-in-line, 5-10
    Proximal occlusion, 5-9
    Self, 1-7, 5-4
Theory of operation, 4-1
    Electronic subsystem overview, 4-2
    General description, 4-1
    Mechanical overview, 4-28
    Printed wiring assemblies, 4-24
    Remote mounted peripherals, 4-27
Transmitter circuitry, 4-20
Troubleshooting, 6-1
    Alarm messages and error codes, 6-2
    Procedures, 6-13
    Technical assistance, 6-1
    Warning messages, 6-1
    With the PVT, 6-13

U

Unpacking, 1-6
User qualification, 1-5

V

V2_5 reference voltage, 4-19
Velcro strap replacement, 7-8
Voltage monitor watchdog timer, 4-5
Volume control knob replacement, 7-14

W

Warning messages, 6-1
Warranty, 2-1

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